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AN INTRODUCTION

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GEOLOGY OF CAPE COLONY

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BY

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WITH A CHAPTER

ON THE

FOSSIL REPTILES OF THE KARROO FORMATION

BY

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OF VICTORIA COLLEGE, STELLENBOSCH

WITH ILLUSTRATIONS AND COLOURED MAP

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PREFACE.

A GENERAL account of the Geology of Cape Colony has long been wanted. The best description yet published is that of the late Professor A. H. Green, "A Contribution to the Geology and Physical Geography of the Cape Colony," which appeared in the *Quarterly Journal of the Geological Society of London* for 1888. This essay is not so difficult to obtain as many other papers published in English or foreign journals, but in some respects it is now known to be inaccurate, and it is of course very incomplete.

In 1895 the Cape Government appointed the Geological Commission for the purpose of organising a Geological Survey of the Colony. The Survey thus established commenced work in 1896, and though its work is still very far from being complete, even as regards the filling up of the inadequate maps that are at present the only available ones for the purpose, yet sufficient information has been collected to

decide many disputed points concerning the fundamental structure of the country, and to enable one to bring the observations of earlier writers on areas that have not been systematically surveyed into harmony with the results obtained. When, therefore, the publishers, on the initiative of Dr. Muir, the Superintendent-General of Education, asked me to undertake the compilation of a geological description of the Colony I agreed to do so, with the consent of the Geological Commission. This work is the first of a series designed by Dr. Muir to promote the study of Natural Science in South Africa.

The chief object of this book is to help students and other people in the Colony to understand the structure of their country and to pursue the subject for themselves. I have, however, taken it for granted that the reader has an elementary knowledge of Geology. There are so many excellent introductory text-books on the principles of the science that it would have been superfluous for me to attempt to combine with this description of Cape Geology what has been well done by others.

The following description is necessarily incomplete, for large areas in the Colony, including the whole of the country north of the Orange

River and immense tracts in the north-western, midland, and eastern districts have not yet been surveyed, and nothing more than the broad outlines of their Geology is known. I have naturally devoted most space to those parts of the Colony that are best known geologically.

The earliest comprehensive geological map of the Colony is that of A. G. Bain (1856), who was a self-trained observer of great ability. His map is at once a proof of his grasp of the structure of the country and a most remarkable work for one man to have accomplished. Other men who were closely concerned in laying the foundations of Cape Geology were Dr. W. G. Atherstone, A. Wyley, G. W. Stow, and E. J. Dunn. A full account of the development of opinion on the more important geological features has been written by Dr. G. S. Corstorphine, under whose direction the Survey was carried on during the first six and a half years of its existence; it will be found in the Annual Report of the Commission for 1897.

In an appendix I have given the titles and dates of papers referred to in the footnotes and made use of in preparing this book. The numbers in brackets after authors' names in the footnotes refer to the year of publication, but in

the case of the Annual Reports of the Geological Commission the number indicates the year on the work of which the Report was written, for the Annual Reports have not appeared regularly. I especially wish to draw attention to the publication of descriptions and figures of Cape fossils in the *Annals of the South African Museum.* The plants of the Karroo and Uitenhage formations, and many of the Bokkeveld fossils have already been dealt with.

There can be few countries whose geological structure has had such an obviously direct influence upon the form of the present surface as is the case in this Colony. The thick soils and rich vegetation, which in more humid climates may be the chief compensation for the lack of facility for the study of Physical Geology, rarely seriously interfere with geological investigation in Cape Colony, though there are parts of our country that may be compared with any in the world in respect of beauty due to vegetation and form combined. Physical geography can be made a very good means of education, and there are few towns or villages in the Colony where a teacher with a knowledge of the subject cannot find striking examples of many important principles within reach of an afternoon's walk.

Encouragement given to pupils to form collections from the neighbourhood is at once the means of their instruction and pleasure, and discoveries of both scientific and practical value may also be the result.

It may be well to point out here that a geological specimen loses at least the greater part of its value and interest in the absence of a record of the locality whence it came, and also that when a large fossil, e.g., a reptilian skeleton in the Karroo formation, is found, it is better to leave it in the rock till some one who understands such things can get it out than to carry away part of it. The partial removal of skeletons has been the cause of great confusion in certain cases, even to the extent of being the cause of two or more generic names for different parts of one species. Should there be no suitable provision for the preservation of fossils in a local museum they should be sent to the public collections, such as the South African Museum, Cape Town, where they will be made good use of. Any available information concerning fossils or rocks can be obtained there.[1]

[1] It may not be out of place to mention that boxes or other parcels of fossils and other natural history specimens addressed to the Directors of the Public Museums are carried free on the Cape Government railways.

I have much pleasure in thanking Professor Broom of Stellenbosch for assistance regarding the names of the reptilian fossils, and for his chapter on the reptiles of the Karroo formation; Mr. F. L. Kitchin, of H. M. Geological Survey, has kindly given me the correct names of the Uitenhage and Pondoland marine fossils and notes on their relationship to foreign Cretaceous faunas; and lastly my best thanks are due to my colleague, Mr. E. H. L. Schwarz, who has made many and valuable suggestions during the preparation of this work, and who gave me the photographs reproduced on Plates vi., xix. and xx., and the notes on the Geology of the Rosmead-Port Elizabeth and Willowmore lines. So much of the field work upon which this account chiefly depends has been done by Mr. Schwarz, and so intimately have we been associated in the Geological Survey of the Colony during the past eight years, that the credit of any advance upon previous views on Cape Geology is very largely due to him. There can be few questions which have suggested themselves during the progress of the Survey that we have not discussed together, usually in the field, and without in the least desiring to make him responsible for views that in the nature of the case are doubtful, and

which are certain to be modified, if not altogether rejected, when fuller knowledge is obtained, I wish to acknowledge my great debt to him.

ARTHUR W. ROGERS.

CAPE TOWN, 29*th March*, 1904.

NOTE ON THE MAP.

THE accompanying map has been compiled from various sources. The south and west, from the Olifant's River to Knysna, inland as far as the Roggeveld-Nieuweveld escarpment, the Prieska district, and the Transkei have been taken from the field maps of the Geological Survey. The rest of the map is based upon the previously published maps of A. G. Bain, G. W. Stow, and E. J. Dunn. The portions of Natal and the Transvaal included within this map are taken from C. L. Griesbach and G. A. F. Molengraaff. The Orange River Colony is filled in according to E. J. Dunn, with modifications due to the work of A. C. Seward and T. N. Leslie on the fossil plants of Vereeniging, etc., and to information that has reached the compiler from other sources.

The dolerite intrusions are only very partially represented, as the details of their distribution north and east of the Nieuweveld - Roggeveld escarpment are unknown; they extend farther north than the limit of this map.

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INTRODUCTION.

THE backbone of the Cape Colony is the watershed between the rivers that drain into the Atlantic and those which flow south and east into the Indian Ocean. The watershed lies in a general east-north-east direction from the neighbourhood of Ceres and Tulbagh, where two systems of mountains converge, the Cederbergen and those parallel to them on the west, with a north and south trend, and the Langebergen and parallel ranges on the south, with an east and west trend (see Fig. 3). The watershed is formed by the Klein Roggeveld, Nieuweveld, Winterbergen, Stormbergen and Drakensbergen, and as a whole it is the highest belt of ground in the country, although certain peaks in the southern and western mountains rise to a greater height than many parts of the watershed. From this main water-parting the surface slopes gradually northward to the Orange River, by which the greater part of the area north of the watershed is drained. Towards the west coast the country which feeds the rivers running directly to the Atlantic south of the Orange River is considerably broken; the two escarpments of the Roggeveld and the Bokkeveld Mountain, which eventually become one feature about eighty miles north of Calvinia, bring the

level of the surface from some 5,000 feet down to 500 feet above the sea. South of the Bokkeveld Mountain (an important escarpment west of Calvinia which must not be confused with the mountains of the Cold Bokkeveld in Ceres) the Cederberg chain commences, and forms, together with its subsidiary parallel ranges, a broad belt of mountainous country rising to the height of 6,000 feet between the Karroo and the coastal district.

The southern drainage slope is also very different in the west and east. In the west there is a sharp drop immediately south of the watershed, and the Great Karroo lies between it and the Zwartebergen, which rise to a height of over 7,000 feet above the sea, and some 5,000 feet above the Karroo. The Zwartebergen, Langebergen, and the minor ranges parallel to them, run nearly east and west, together forming a wide tract of mountainous country which stretches from Tulbagh to the Indian Ocean east of Grahamstown. This belt is traversed by the rivers flowing from the Karroo, generally in deep, steep-sided valleys, which become gorges in the mountain ranges. There are many longitudinal valleys in this region much more open and less steeply graded than those of the transverse rivers into which their waters flow. The country between the Zwartebergen and Langebergen, occupied by longitudinal valleys, lies somewhat lower on the average than the Great Karroo. South of the Langebergen the surface slopes towards the coast, but it is deeply cut into by rivers, and diversified by mountains such as Aasvogel Berg, Pot Berg, and the mountains of Calèdon and Bredasdorp.

In the eastern part of the Colony, beyond the Gualana River where the southern mountainous region is cut through by the coast, the descent from the watershed to the coast is more uniform than in the west; it is unbroken by mountain ranges, but is more of the nature of a succession of terraces than a gradual slope. There is no area in the east corresponding to the Great Karroo of the west and midlands; the rain borne by the south-east winds waters the Eastern Province from the coast to the watershed, but the Great Karroo is deprived of this source of water by the mountains on its southern border.

The geological structure of the Colony is in its main outlines fairly simple; the country may be looked upon as a shallow basin filled in with nearly horizontally lying rocks, those of the Great Karroo system. The character of the edge of the basin is very different in the north and south, and the basin form is due rather to movements in the earth's crust, which took place after the deposition of the rocks now filling the basin, than to the original shape of the surface on which the rocks were laid down.

Before describing further the structure of the Colony, it will be convenient to give a general account of the various groups of rocks that build it up. The classification of these rocks, which will be used in this book, is as follows:—

Recent and sub-recent deposits :—	Sand dunes and consolidated dunes, calcareous tufa ; alluvial deposits and gravels of low and high levels ; laterite and surface quartzite.	
Cretaceous system	Cretaceous series of Pondoland.	
	Uitenhage series	Sunday River beds. Wood beds. Enon conglomerate.
Karroo system	Stormberg series	Volcanic beds. Cave sandstone. Red beds. Molteno beds.
	Beaufort series	Beds containing Theriodonts. Dicynodon beds. Pareiasaurus beds.
	Ecca series	Shales and sandstones. Laingsburg beds. Shales and sandstones.
	Dwyka series	Upper shales. Conglomerates. Lower shales. (Unconformity in north.)
Cape system	Witteberg series. Bokkeveld series. Table Mountain series.	
Pre-Cape rocks	In south and west:— Ibiquas series. Cango series. ? ? Malmesbury series.	In north and north-west :— Matsáp series. Volcanic rocks of Beer Vley, etc. ? Griqua Town series. Campbell Rand series. ? ? 'Keis series. ? ? Namaqualand schists.

Unconformable bases are indicated thus :

The Pre-Cape rocks include a great variety of sediments, of which the original characters have in most cases been greatly changed by the pressure exerted

during the earth movements that took place before the deposition of the rocks forming the Cape system; the movements subsequent to the Cape system probably affected the Pre-Cape rocks in the south and west of the Colony only. The intrusion of the great masses of igneous material, mostly of an acid type, previously to the formation of the Cape system, brought about considerable alteration in the Pre-Cape rocks in the south, west, and north of the Colony. The subdivisions of Pre-Cape rocks and their igneous intrusions will be described in the next chapter, and further details are not necessary at this stage. It is sufficient to note that the ages of these rocks—for we shall find that they include several independent formations separated by great unconformities—are unknown, except that they are older than the Cape system. As yet, no organic remains have been described from the Pre-Cape rocks, and it is therefore impossible to correlate them with the rocks of foreign countries. The Pre-Cape rocks occur in the south-west and north of the Colony, and form vast tracts of country in the north-west (Namaqualand, etc.) and to the north of the Orange River.

The Cape system is composed of sandstones, quartzites, shales and mudstones, arranged in three series. The lowest or Table Mountain series is chiefly sandstone, with occasional pebbles of white quartz; beds of conglomerate are rarely seen; two thick bands of shaly material are usually met with, one near the top and one near the bottom of the series. The approximate maximum thickness of the series is 5,000 feet. The group

forms the great coastal ranges of the Colony, and takes its name from Table Mountain behind Cape Town.

The second group in the Cape system is the Bokkeveld series; it comprises shales and thin sandstones interbedded with thick layers of more or less argillaceous sandstones, which are arranged in a definite order recognisable over wide areas. The maximum thickness of the Bokkeveld series is about 2,500 feet. Towards the lower part of the series considerable numbers of fossils occur; they are marine forms, and some of them are identical with or closely related to species which are found in Devonian rocks of America and Europe. They afford the earliest evidence we have for the chronological comparison of the geological history of the Colony with that of other countries. The Bokkeveld series occupies wide areas in the south of the Colony, and takes its name from the Warm and Cold Bokkevelds in Ceres, where it is typically developed. Wherever the base of the series is seen the junction with the underlying Table Mountain series is a conformable one.

The Witteberg series, a group of shales, thin sandstones and quartzites, about 2,500 feet thick, is the highest division of the Cape system. It contains, so far as is known, very few fossils, and these are of vegetable origin. The series takes its name from the Wittebergen, south of Matjes Fontein, in the south of the Karroo, and forms several long and high ranges of foot hills north of the Zwartebergen. It lies conformably upon the Bokkeveld series.

The Cape system rests unconformably upon the older rocks wherever the junction between them has been

observed. Between Karroo Poort in the west and the Gualana River in the east, the lowest beds of the Karroo formation rest conformably upon the highest of the Cape system. To the north of Karroo Poort, however, the Dwyka series is found to lie upon lower and lower members of the Cape system as it is followed northwards to the end of the Bokkeveld Mountain, where it rests directly upon the Pre-Cape rocks. Near the mouth of the Gualana River the Cape system disappears beneath the sea, and where it reappears in Pondoland the two upper members are missing, and the Table Mountain series is unconformably overlain by the Dwyka conglomerate.

The Karroo system forms by far the greater part of the surface of Cape Colony; from the 33rd parallel of latitude northwards to the Orange River, with the exception of the country west of the Prieska division, the rocks belonging to this system form practically the whole surface of the country. Outliers of the Karroo system, including at least the two lower series, have been found south of the main area occupied by it; they are insignificant in extent, but they are important on account of the evidence they afford of the former southward extension of the Karroo rocks. By far the most interesting outlier is that between Worcester and Robertson, where the Dwyka and Ecca have been faulted down against the Malmesbury (Pre-Cape) beds.

The Dwyka series forms the base of the system, and occurs as a continuous band round the area occupied by the higher beds. The series consists of a varying but

usually considerable thickness of conglomerate, which is both overlain and underlain by shales in the south of the Colony; in the west and north, where the Dwyka rests unconformably upon the older rocks, the lower group of shales is absent. The maximum thickness of the series is over 2,000 feet. The conglomerate is of very great interest on account of its glacial origin.

The Dwyka series is overlain conformably by the Ecca, a group of shales and sandstones containing plant remains belonging to several genera found in many other parts of the world, and these fossils form the second important bench mark for comparing the rocks of the Colony with those of other countries. The thickness of the Ecca beds is about 2,000 feet in the west of the Karroo, and some 2,600 in the south-west and south.

The Beaufort series, distinguished by containing the remains of several forms of reptiles, succeeds the Ecca without any break in the western Karroo, in fact it is often difficult to draw the line between the two series. Shales, mudstones and sandstones, to the thickness of at least 3,000 feet, compose the Beaufort series, which is so named from its occurrence in Beaufort West and Fort Beaufort.

The boundary between the Beaufort and the overlying Stormberg series has never yet been closely defined. The Stormberg beds contain a number of plants and reptiles distinct from those in the underlying rocks, by means of which they can be readily identified. The lower part of the series consists of shales and sandstones with seams of coal. At the top of the ordinary

sedimentary rocks in the Stormberg group there is in places a peculiar set of beds called the Cave sandstone, with which are associated the lowest of the volcanic rocks of the Stormbergen and Drakensbergen. The thickness of the Stormberg beds, excluding the volcanic rocks, is perhaps about 3,000 feet, and the volcanic beds in some localities must be 4,000 feet thick. The uppermost portion of the series has been removed by denudation, and the volcanic beds now form the highest points of the surface of the Colony, the peaks of the Drakensberg in East Griqualand. So far as is known at present the Stormberg series only occurs in the higher parts of the country east of Steynsburg; outside our limit it forms the greater part of Basutoland.

One of the chief characteristics of the country occupied by the rocks of the Karroo system is the abundance of dolerite intrusions which are met with in all parts of the system from the Dwyka to the Stormberg series. It is not unlikely that these intrusions belong to one period of igneous activity, which commenced during the deposition of the Stormberg series, and that they were closely connected in origin with the volcanic outbursts that took place towards the close of the Stormberg period.

The rocks belonging to the Cretaceous system in the Colony are divided into two groups, which occur in widely separated localities and in different manners, but the evidence of the fossils is sufficient to prove that one group is considerably older than the other, although both present close affinities to the Cretaceous rocks of other parts of the world.

The older, or Uitenhage, series forms several disconnected areas between Worcester in the west, and Alexandria in the east of the Colony. The lowest part of the series is almost always a conglomerate, usually overlain by shales and sandstones containing the remains of fresh-water and land animals and plants; in the eastern districts the beds of fresh-water origin are in turn overlain by clays, shales and limestones with marine fossils, related to forms found in the Lower Cretaceous and Upper Jurassic of foreign countries. The more important areas of the Uitenhage formation are in the divisions of Uitenhage, Knysna, Oudtshoorn and Riversdale. The Uitenhage beds everywhere lie unconformably upon the older rocks, from the Pre-Cape to the Ecca. The unconformity is always very pronounced, and proves that the older beds had been intensely folded and had been exposed to denudation for a long period before the Uitenhage beds were deposited. The maximum thickness of the series is probably not less than 2,000 feet, but the top of it is nowhere seen.

The chief outcrop of the Pondoland Cretaceous series occupies a narrow strip of country, about ten miles long and half a mile wide, on the Pondoland coast. It is faulted down against the Table Mountain series. The rocks are sandy clays and shelly limestones remarkably rich in fossils, many of which are related to, or identical with, species that are found in the Cretaceous rocks of Southern India. A similarly situated strip of conglomerate and sandstones is found near the mouth of the Embotyi River, and very probably belongs to the same

series, but palæontological evidence to prove this point has not yet been found. The Embotyi rock is of great interest on account of the boulders of Karroo dolerite imbedded in it.

The Recent deposits of sufficient importance to be mentioned here are the sand dunes, and the limestone resulting from their consolidation by the deposition of carbonate of lime from solution between their component grains; these rocks are found on many parts of the coast; the quartzitic sandstones and conglomerates, produced by the cementation of sands and gravels of alluvial origin, found over wide areas between Malmesbury in the west and the Transkei in the east; and certain rocks related to laterite. These are all found lying unconformably upon the older rocks in their neighbourhood, generally in thin layers, but in places the limestone derived from dune sand may reach a thickness of 500 feet. So far as the fossils in these rocks have been determined they all belong to species still living in South Africa.

It has already been stated that the structure of the Colony may be likened to a shallow basin occupied by the Karroo formation. The basin extends much farther than the limits of the Colony, for its northern edge traverses the Transvaal in a north-easterly direction, and practically the whole of the Orange River Colony, Basutoland, and part of Natal, lie within it. On the south-east the edge of the basin is cut into by the Indian Ocean between the Gualana and St. John's Rivers.

For the purpose of a more detailed description, the Colony may be divided into three regions: (1) that of the Pre-Cape rocks of the north and west; (2) the belt of folded rocks belonging to the Cape and Karroo systems, extending from near Van Rhyn's Dorp to the neighbourhood of the Peninsula, then turning eastwards and finally disappearing beneath the sea near the Gualana River; (3) the region of the plains and plateaux of the interior of the Colony, the area lying within the basin, part of whose edge is formed by the first two regions. This division of the Colony, while convenient for descriptive purposes, brings out strongly the contrast between the northern and southern edges of our basin.

(1) The region of the Pre-Cape rocks in the north and west of the Colony is largely composed of granite and foliated rocks of igneous origin; the sedimentary beds invaded by these, together with more recent beds of Pre-Cape age, form, however, great areas in the north and in the south-west.

The nature of the rocks and the structure of the country are less known than those of either of the two other regions, especially in the case of the vast semi-desert country lying west of Prieska. In Prieska, and the country north of the Orange River in that neighbourhood the folds into which the rocks have been thrown have a marked effect upon the surface features; the Doornbergen, for instance, are a range of hills trending north-west along the strike of the rocks composing them, and the Ezel Rand, lying almost at

right angles to the Doornbergen, is found to consist of sedimentary rocks with a corresponding north-easterly strike. The same appears to be the case with the Kaap plateau, the Langebergen, and other ranges in Griqualand West described by Stow.[1] Some of these features are of very great antiquity, older than the Dwyka conglomerate, which rests in the valleys between the hills. These ranges do not reach a great height above the surrounding low ground, and are different in this respect from the mountains of much later origin that diversify the second and third regions. Stow[2] noticed the remarkably rounded form of many of these hill ranges, and attributed them to glacial action, but to glaciation of a much more recent date than can now be admitted; for since these rounded surfaces have been found passing under the glacial conglomerate at the base of the Karroo formation, we must conclude, in the absence of evidence of recent glaciation, that all the characteristic glacial features observed on the ancient surface were produced during the Dwyka period. The main surface features of the Pre-Cape rocks of Prieska are thus probably due to denudation during Dwyka and Pre-Dwyka times; they have been buried under an unknown thickness of rocks belonging to the Karroo formation, and have been gradually exposed again by the removal of these overlying beds. The north end of the section in Fig. 1 illustrates the relationship of the Karroo formation to the underlying rocks of Prieska.

The strike of the Pre-Cape rocks in Griqualand West and the trend of the hills carved out of them is north-

[1] Stow (73). [2] *Ibid.*, p. 666.

4. Bokkeveld series.
5. Witteberg series.
10. Uitenhage series.

The part of the section traversing Carnarvon is based upon a superficial acquaintance with the country 70 miles further east, and is merely intended to illustrate the type of structure met with north of the Nieuweveld; the parts north and south are founded on observations of the Geological Survey.

easterly, while the same rocks in Prieska have usually a north-west strike. In the south of the Colony the strike of the Pre-Cape rocks has an intimate connection with the trend of the folds which involved the Cape formation and the lower members of the Karroo system, the result of earth movements that did not affect the northern area.

West of the Prieska district lie Kenhardt and Little Namaqualand, including the very dry and sandy area called Bushmanland. Beyond stating that there are great tracts of granite and gneiss, the disintegration of which gives rise to the sand covering large parts of Bushmanland, there is little to be said about that country at present owing to lack of knowledge. In Little Namaqualand there is much granite and gneiss continuous with the similar rocks of Bushmanland, and the Namaqualand schists, partly metamorphic rocks of igneous origin. The country is hilly with much sand in the valleys, and the river courses are ill defined, as is usually the case in the dry districts in the north of the Colony. Some outliers of quartzites are stated by Mr. Dunn to belong to the Witteberg series, otherwise there seem to be no rocks later than those of Pre-Cape age in the north-west, outside the limit of the Karroo formation which bounds the region on the south and east.

South of Namaqualand the coast country lying west of the escarpment in the north, and the folded ranges further south that bound the coastal plains on their inland side, falls within the first region, which reaches the shores of False Bay. The southern part of this area is studded with large and small outliers of the

Table Mountain series, which must formerly have covered the whole of it, at least as far north as the 31st parallel. The greater part of the area consists of slaty rocks with high dips striking some degrees west of north, more or less parallel with the ranges of folded rocks forming the eastern boundary of the region south of the Doorn River. Several large masses of granitic rocks intrusive in the slates form important ranges of hills; the chief one is that which extends from St. Helena Bay southwards to Mamre, a distance of some seventy miles; other hills of granite are the Paarl Mountain, and the Paarde Berg-Malmesbury range. These granite hills, and the smaller ones carved out of Malmesbury beds, owe their preservation more to the weather-resisting qualities of the rocks which form them than to their structure, though the parallelism of the trend of the ranges with the general strike of the rocks shows that the structure of the area has determined its leading features. It is difficult to discover how far the present surface features are due to denudation effected since the removal of the covering of Table Mountain sandstone, but the occurrence of large hills of Pre-Cape rocks near areas of that sandstone, such as the Lion's Rump near Cape Town, and the slate hills at the south-east end of Riebeek's Kasteel, point to the protection afforded these slate hills by former extensions of the sandstones of the Lion's Head and Riebeek Kasteel now removed by denudation. In the Prieska district we find that the main surface inequalities of the Pre-Cape rocks are older than the Karroo formation that once covered them, but a corresponding relation be-

tween the surface features of the Pre-Cape rocks in the south-west and the overlying Table Mountain series has not been made out, in fact the evidence so far as it goes, *e.g.* the approximately plain surface of granite and slate under the northern boundary of the Peninsula outlier, points to the present surface features in the Cape, Malmesbury and Stellenbosch Divisions being due to denudation since the removal of the bulk of the Table Mountain series.

The southern part of the region is, in marked contrast to the northern portion, a well-populated, fertile land, in which good crops are raised annually and the wine and fruit-growing industries are second to none in the Colony. In the north, except in the as yet small areas watered by artificial irrigation, but little in the way of agriculture is attempted, and cattle and sheep are the mainstay of the farmers.

(2) The second region is the folded belt which runs in a southerly direction from Van Rhyn's Dorp to the neighbourhood of the Peninsula, there turns eastwards, and is continued as far as the mouth of the Gualana River, where it is cut off by the sea. This area is chiefly composed of the three members of the Cape system, the lowest of which, the Table Mountain series, forms the mountain ranges of the Cederbergen, Drakensteins, Langebergen and Zwartebergen, to mention only some of the more important ones, which are such striking features in the south of the Colony. In addition to the Cape formation, the lower parts of the Karroo system, the Dwyka and Ecca series are involved in the folding,

and this fact has great significance in that it proves that the folding took place chiefly after the deposition of the Ecca series. The later limit of the period during which the folds were produced is fixed by the presence of considerable areas of comparatively undisturbed beds belonging to the Uitenhage series lying upon the upturned edges of the folded rocks belonging to all ages from Pre-Cape to Ecca.

The folded belt is flanked on the outside by the Pre-Cape region in which these earth movements produced but little effect, and on the inner side by the almost horizontal strata of the Karroo. The Cape Peninsula and the districts north of it where the Table Mountain sandstone lies nearly flat are on the outer side of the folded belt in the Pre-Cape region.

At its broadest part the folded belt is about 100 miles wide, from the southern part of the Karroo to Cape Agulhas, and its length along the bend is some 600 miles. The most marked character of the region is the presence of many mountain ranges, which are mostly formed by great anticlinal or arch-like ridges of the folded strata. A glance at the map will show that the general trend of these mountains is roughly parallel to the coast; on the western side the Cederbergen, Witzenbergen, Cold Bokkeveld Mountains, and other minor ranges, run a little west of north; while on the south, where the Langebergen, Zwartebergen, and other ranges of less importance, lie nearly east and west, the coast line makes a corresponding change in direction, but towards the east the coast cuts diagonally across the folded belt. In the districts between Ceres

and Bredasdorp there is an intermingling of the east and north trending folds, forming an area where the forces that produced these folds have given rise to a clearly marked diagonal set with a north-easterly course; the chief ranges due to these north-easterly folds are the great mass extending somewhat irregularly from Cape Hangklip to the mountains south of Worcester, the Hex River Mountains, and the south-west continuation of the Babylon's Tower range south of Caledon. The mountain ranges with a north-east trend are traversed by a weaker system of north-west folds, and are thereby broken up to a certain extent, especially by the synclines or trough-like folds of Houwhoek and Villiersdorp. The intricate effects of the contest between the two sets of forces, that which produced the Cederberg (north and south) system of folds, and that which produced the Zwartberg (east and west) system, so far as the Caledon and Bredasdorp districts are concerned, have been described in some detail in a survey publication.[1]

There is some evidence in favour of the view that the Cederberg system of folds began to be formed rather earlier than the Zwartberg, but probably each reached its greatest development at about the same period, at some time between the deposition of the Ecca and that of the Uitenhage series.

The folding is most intense in the east and west trending portion of the rocks involved. Northwards from the country between Tulbagh and Karroo Poort

[1] *Geol. Comm.*, 1898, p. 42, etc.

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It has been stated that the folded belt disappears under the sea near the Gualana River, and it would be interesting to find out what becomes of it farther east. It is, of course, impossible to discover the exact state of affairs, but a comparison of the structure of the seaboard of Pondoland with that of the Van Rhyn's Dorp end of the folded belt will give us a clue to it.

In Pondoland some of the rocks which form the folded belt in the south of the Colony reappear on the coast near the St. John's River, but are very different in certain respects from their condition west of the Gualana River. They are found to be very slightly folded; the great anticlines of the south and west have no counterpart there, and the greater part of the Cape formation is altogether absent. The rocks emerge from the ocean with a northerly trend, instead of the east and west strike which they have in the south. At St. John's there is a great block of Table Mountain sandstone, surrounded on all sides by beds belonging to the Karroo formation faulted down against it, but further north-east towards Natal the Dwyka rests unconformably upon the Table Mountain series (see Fig. 4); the accounts[1] of the geology of Natal show that the same condition obtains there, and also that the Table Mountain sandstone (Palæozoic sandstone of Anderson) becomes thinner as it is followed northwards, and finally disappears, so that the Dwyka series rests directly upon rocks of Pre-Cape age. The relation of the Dwyka conglomerate to the Table Mountain sandstone in

[1] Griesbach (71), p. 59 and map; Anderson (01).

Pondoland is thus just like that of the same two series in the Bokkeveld Mountain north-east of Van Rhyn's Dorp.

If we imagine the country between Karroo Poort and the latitude of Van Rhyn's Dorp to be removed from observation, we have a nearly similar condition of things on each side of the folded belt, extending from Karroo Poort to the Gualana River, but the relatively raised block of the Gates of St. John's has no analogue in the west. The gradual flattening out of the folds northwards of Karroo Poort has no obvious counterpart in the east of the Colony, simply because the area in which a similar change takes place is under the sea. There is no reasonable doubt that on the sea floor between the Gualana River and St. John's, first the Witteberg and then the Bokkeveld beds disappear, owing to Pre-Dwyka denudation, and that the Dwyka series rests upon lower and lower members of the Cape system, so that in Pondoland it lies directly upon the Table Mountain series, just as it does north of the latitude of Van Rhyn's Dorp. It is very probable that, as in the west, the folds become less marked and practically die out altogether in the same area that shows the thinning out of the Cape system, so in the east, the two changes go on together. The comparison of the structure of the northward termination of the folded belt in the west and east of South Africa shows that this end of the continent is built upon a more symmetrical plan than might have been suspected from a mere inspection of the geological map.

The folded belt includes the more thickly populated

districts of the Colony outside the Native Territories. Nearly all the various kinds of farming practised in South Africa can be found within this region. The most fertile and valuable land is that situated along the larger rivers flowing through from the Karroo, enriched by the silt brought down by them. The poorest soil is found on the sandstone mountains and near the coast, where the natural vegetation is of the kind known as "sour veld". In a region so diversified in climate and rocks as the folded belt, there are naturally many varieties of soil, and we shall have an opportunity of noticing some of these in later chapters.

(3) The limit between the folded belt and the third division of the Colony, the region of the plains and plateaux of the interior, cannot be precisely defined, as the folds die out gradually as one traverses them towards the interior; the rocks become practically flat at a distance of some twenty miles from the great anticline of the Zwartebergen on the south of the Karroo; on the west of the Karroo the distance between the Cederberg anticline and the nearly flat beds to the east is much less. Near the Nieuweveld and Roggeveld escarpments there are several small flexures, usually more or less parallel to the axes of the Zwartberg folds, but they have slight effect on the surface features, and do not detract from the plateau character of the country they traverse.

The wide plains of the Great Karroo, and the even more extensive plateaux of the country north of it (often called the Upper Karroo), with sharply defined

steep-sided hills standing on them, are amongst the chief characteristics of the third region. Eastward of the Great Karroo, approximately bounded by a line drawn between Aberdeen and Jansenville, the structure of the country is essentially the same as that of the western part of the region, but owing to a more general distribution of rain, due to the absence of the coastal ranges which prevent the moisture-laden south-east winds carrying rain to the interior in the west, the eastern portion of the region is better covered with vegetation than the western; the thicker covering of vegetation in the east, which becomes more marked as one approaches the coast, softens the features of the surface, the hill slopes are more rounded and less abrupt, and the distinction between harder and softer rocks is less obvious than in the Karroo.

The sedimentary rocks of the third region lie nearly horizontally, but a careful examination shows that they usually dip at a very low angle towards the central part of the basin. Thus in the western Karroo and Roggeveld the beds dip east, to the north of the main watershed the dip is usually south or a little east of south, and to the south of it the beds are inclined slightly to the north or west of north. These sedimentary rocks belong exclusively to the Karroo system, but with them are found intrusive igneous rocks, dykes, sheets and great masses, probably lenticular in shape, of dolerite. The dolerite intrusions are of sufficient importance to have a chapter devoted to them, and at present only the chief facts relating to their distribution will be mentioned. From the western border of Calvinia east-

wards to the Indian Ocean, and from the Nieuweveld escarpment northwards to the Orange River, and even far beyond the river, the sedimentary rocks are traversed by sheets and other masses of dolerite to such an extent that it is hardly an exaggeration to say that within the area of some 70,000 square miles one cannot get out of sight of the dolerite hills. This area is but a part, perhaps not much more than half, of the whole range of the dolerite intrusions in South Africa. Though the dolerite is so widely distributed, and varies somewhat in composition and structure, it has an individuality of its own, and can be distinguished from similar rocks in the Colony belonging to earlier periods of igneous activity. It is a remarkable fact that intrusions of this dolerite are extremely rare in the folded belt, and also in those parts of the Karroo basin on the margin of that region. In the Bokkeveld Mountain west of Calvinia, where the Table Mountain series lies almost horizontally, and in the Brandewyn valley (Clanwilliam), where the Cape formation is but slightly folded, dykes of dolerite of the Karroo type occur. In Pondoland also, where the Table Mountain sandstone lies nearly undisturbed, the dolerite has invaded it. Throughout the folded belt south of the Karroo not a single intrusion of this nature has been found.

The dolerite intrusions have a very important effect on the surface features of the country, owing to their being less easily weathered than most of the sedimentary rocks associated with them. The steep escarpments of the Nieuweveld and Roggeveld owe their abrupt faces to this rock, for the more easily weathered sedimentary

rocks form steep slopes at the bottom of vertical cliffs of the dolerite or sedimentary rocks hardened by contact with it. In the Komsberg, which lies between the Roggeveld and Nieuweveld, there is no dolerite, and although a somewhat similar *rôle* to that of the dolerite is played by some hard bands of coarse sandstone, the escarpment is less precipitous than either of the other escarpments.

The well-known table-shaped hills scattered broadcast over the interior of the Colony owe their form to a protecting cap of hard rock, either sheets of dolerite or beds of sandstone; the finest examples of such hills are found amongst those capped by dolerite. Tafel Berg and Spitzkop, two outliers of the Western Nieuweveld, which rise some 3,000 feet above the Gouph and are visible from the railway between Prince Albert Road and Beaufort West, are magnificent hills of this type, and are capped by a dolerite sheet 400 feet thick. Other instances, of smaller size but quite as striking, are the hills called Theebus and Kaffeebus, near the railway between Steynsburg and Rosmead.

A great part of this region is covered with small bushes, but the eastern portion is a grass country. The Great Karroo, Roggeveld and Nieuweveld are chiefly sheep veld, but the flat land along the rivers is extremely fertile when brought under irrigation. To the north of the main watershed very large areas of alluvial deposits along the rivers, such as the Zak and Rhenoster, await cultivation. Owing to the cold winter climate of the higher parts of the Roggeveld and Nieuweveld the farmers there have to take their flocks to

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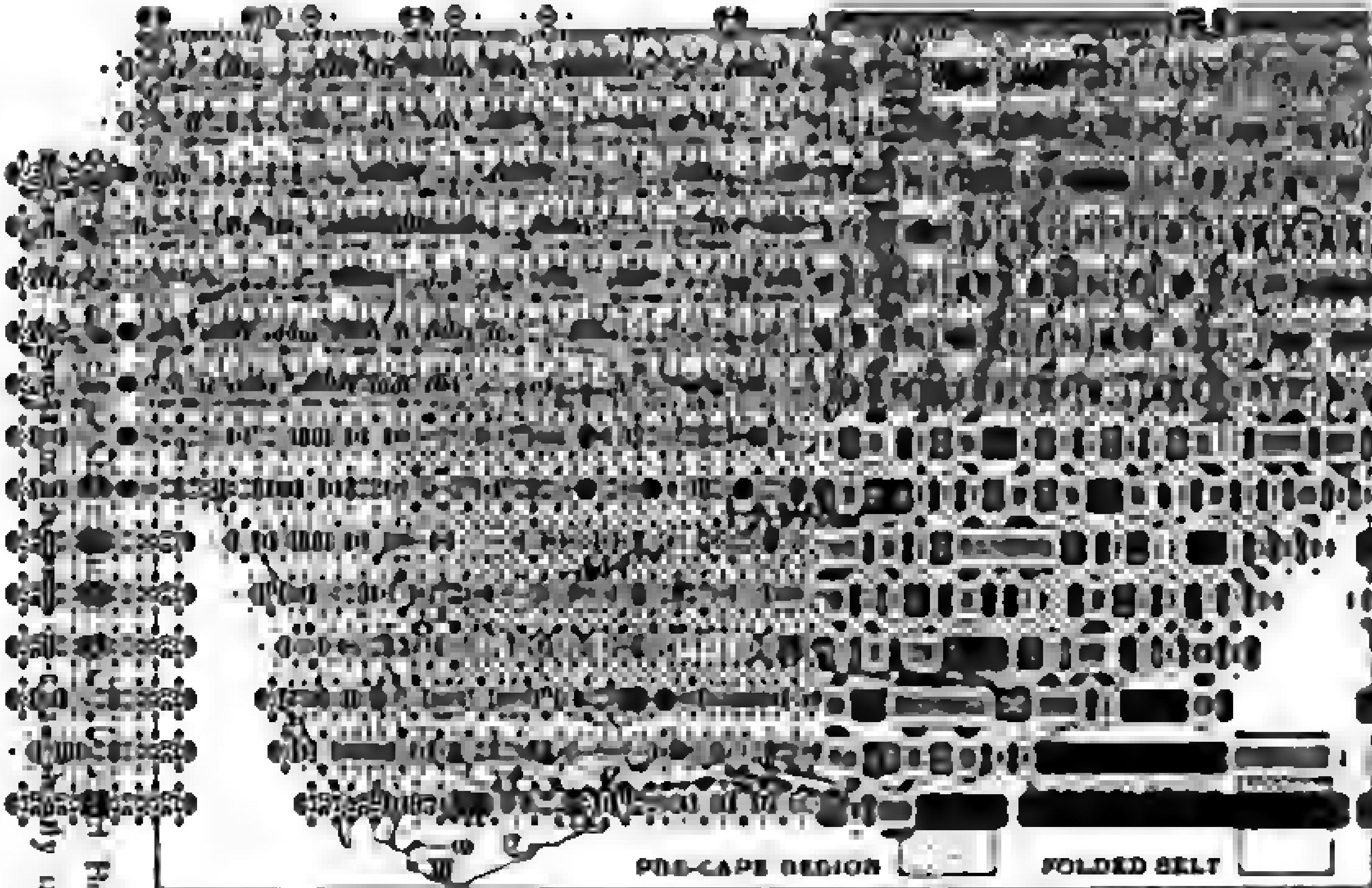

FIG. 8.—Diagram to show the three regions in Cape Colony and adjacent tr... of the line to north and north-east between Pre-Cape and Karroo basin regions.

The chief mountain areas in folded belt are:—

1. Cederbergen.
2. Olifant's River Mountains.
3. Hex River Mountains.
4. [illegible], etc.
5. Langebergen, etc.
6. [illegible], etc.
7. Gouga Mountains.
8. [illegible] Mountains.
9. [illegible] Berg.
10. Zuurberg and [illegible] range.
11. Zwartebergen.
12. [illegible].
13. [illegible] Berg.
14. [illegible] Berg.
15. Warm Water Berg.
16. [illegible] Berg.
17. [illegible] Berg.
18. [illegible] Range.
19. [illegible] Range.
20. [illegible] Mountain.
21. [illegible] Mountains, etc.

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south at the present time than it did at the period of the greatest northward extension of the water in which the Karroo formation was deposited; but, as we shall see when we describe in detail the lower part of the Karroo system, the present position of the northern edge, although due immediately to the progress of denudation, must lie approximately along a former course of the Karroo shore at a certain period of its existence. The southern edge of the basin, on the other hand, is entirely due to the exposure of the Pre-Karroo rocks by denudation in a folded area. That the Karroo rocks formerly extended far to the south of the Karroo is proved by the occurrence of outliers of the two lowest series in the district between Worcester and Ashton, where they are faulted down against the Malmesbury beds on the north, but lie conformably

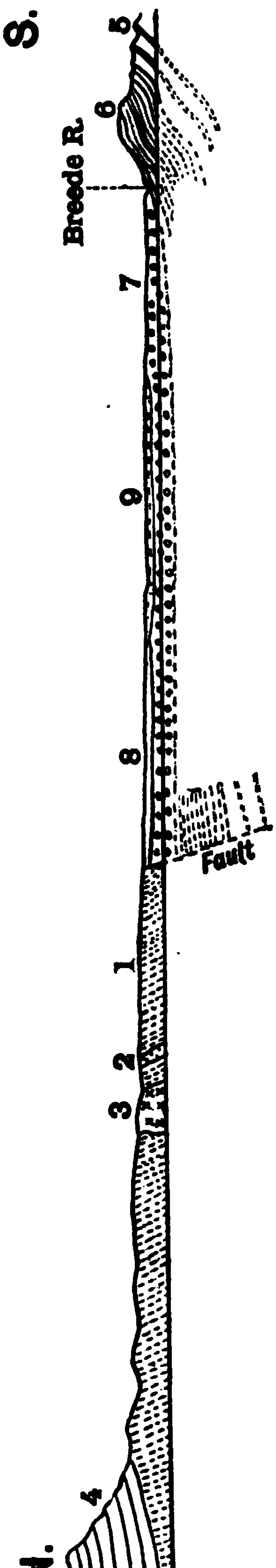


FIG. 5.—Section through the Worcester Fault. Distance 12 miles. Vertical scale $\frac{1}{10}$ in. to 1,000 feet.

1. Slates, etc. } Malmesbury series.
2. Limestone } Malmesbury series.
3. Granite.
4. Table Mountain series.
5. Bokkeveld series.
6. Witteberg series.
7. Dwyka series.
8. Ecca series.
9. Uitenhage series.

upon the Witteberg series along their southern boundary. The discovery of the true character[1] of the Worcester outlier (see Fig. 5) is perhaps the most important addition to our knowledge of the structure of the Colony made during recent years, for it greatly strengthened the evidence for the conformity of the Dwyka series with the uppermost series of the Cape system, and at the same time afforded a clue to the structure of the Langebergen, which has been found to solve many of the difficulties met with in that range and also in the Zwartebergen. There is no direct evidence as to the position of the southern limit of the area in which the Karroo formation was deposited.

The great crumpling of the earth's crust in the south of the Colony was so violent at many places that the rocks are inverted and the older lie above the newer; that is particularly noticeable along both the Zwartebergen and Langebergen, and is illustrated in Figs. 1 and 6. The overfolding seems usually to be towards the north, in other words, the folds are bent over northwards, so that the dip of the strata is towards the south. The country whose southern termination is the third region in our description seems to have served as an immovable block against which the rocks were crumpled on the south, and south-west, and possibly south-east sides. These great movements of the crust, more important to the present structure of the Colony than any others that have affected the southern end of the continent, seem to have been limited to that region. There

[1] E. H. L. Schwarz, *Geol. Comm.* for 1896, pp. 27-28.

appear to have been no great movements of the same age in the country lying north of the Cape Colony; the disturbances met with in the rocks which Dr. Molengraaff calls the Cape formation[1] in the Transvaal are clearly older, for they do not affect the Dwyka and Ecca beds. A similar reason must be given for regarding the plications of the Pre-Cape rocks of Prieska and Griqualand West as of greater age than those belonging to the Zwartberg and Cederberg systems of folding.

There are several other structural features of importance which will be better understood by the reader after a closer acquaintance with the character and distribution of the various formations has been made, and they will be especially referred to in the chapter dealing with the history of the development of the Colony.

[1] *I.e.*, the Black Reef, Dolomites, Pretoria beds and Waterberg sandstones.

[Since this was written Dr. Molengraaff has named this group the Transvaal formation to distinguish it from the later Cape system.]

CHAPTER II.

THE PRE-CAPE ROCKS OF THE SOUTH AND WEST OF THE COLONY.

THE various groups of rocks included under this heading have one character in common, they are older than the Cape formation. In the case of three of the groups, Ibiquas, Cango and Malmesbury, their Pre-Cape age is obvious from the fact that they are found directly beneath the Table Mountain series; but in the case of the northern groups, which are found in a region where the Cape formation was either not deposited or has since been removed by denudation, their age has to be arrived at by reasonings based upon the structural features of the country, for no help in correlating these formations is given by fossils.

THE MALMESBURY SERIES.

In the south-western districts sedimentary rocks are in many places met with immediately below the Table Mountain series. These rocks were evidently intensely disturbed, invaded by granite and other igneous rocks, and long exposed to denudation before the deposition of the Table Mountain sandstone. In the immediate neighbourhood of Cape Town the Table Mountain

sandstone, which forms all the higher parts of the Peninsula, lies nearly horizontally, and below it are seen slaty rocks dipping at very high angles, with a general north-north-west strike, accompanied by a large intrusion of granite. The slaty rocks are found to extend northwards from the foot of Table Mountain at least as far as Van Rhyn's Dorp, occupying the greater part of the divisions of Malmesbury, Piquetberg, Paarl, Stellenbosch and Somerset West. This large area of Malmesbury beds is separated by the range traversed by Bain's Kloof, and called the Limiet Berg, Eland's Kloof and Vogel Valley Mountains in different parts of its length, from a rather narrow strip of similar rocks occupying the long depression between Winter Hoek, north of Tulbagh, and Worcester; near the latter town the strip of Malmesbury beds becomes thinner, and extends south-eastwards as far as Swellendam as a narrow band overlain to the north or north-east by the Table Mountain series, but cut off on the south or south-west by a fault (the Worcester fault) which has a down-throw of some 10,000 feet near the town of Worcester (see Fig. 5). Inliers of similar rocks have been found at French Hoek, Eland's Kloof (near Villiersdorp), in the Zondag's Kloof east of Stanford (Caledon division), and between Elim and Bredasdorp. Each of these inliers is surrounded by the sandstones of the Table Mountain series. Rocks that can best be placed with the Malmesbury beds occur also in Mossel Bay, George and Port Elizabeth.

The most abundant rock in the series is a sandy clay-slate with imperfectly developed cleavage. Small

flakes of white or yellowish mica are frequently sufficiently abundant to give the rock a micaceous appearance when broken along the cleavage planes. This mica is easily distinguished from the reddish-brown mica so strongly developed in the clay-slate taken from the immediate neighbourhood of the intrusive masses of granite, and generally only visible under the microscope. In certain localities, such as the hills north-east of Moorreesburg and the Tygerberg group, the proportion of quartz grains increases so greatly that the rocks may be called impure quartzites, and in other places fairly pure quartzites occur, but they are not often met with. Crystalline limestone or marble forms thick bands in the Malmesbury series near Van Rhyn's Dorp, Piquetberg, Vogel Valley (south of Porterville Road Station), at Bakoven's Hoogte between Ashton and Swellendam, in Dassies Hoek near Robertson, and in small quantity north of Worcester. Many other varieties of rock are met with near the contact with the granite, but these will be mentioned later. Ottrelite- or chloritoid-schists are found in rather thin bands near the junction of the slates, which have evidently been intensely compressed, with the unconformably overlying Table Mountain series in Waai Kloof, near Worcester (Plate I.), and north of the village of Swellendam. In both cases thick quartz-schists occur on one side of the ottrelite-schist, but no granite or other intrusive rock is found in the immediate neighbourhood, and as ottrelite-schist has not been seen near any of the granite areas in the Colony, these are probably two further examples of the production of ottrelite by pressure metamorphism

PLATE I.—Waai Kloof, Worcester. The Table Mountain sandstone is folded and lies unconformably upon the quartzites and ottrelite-schists of the Malmesbury beds.

without the concurrence of the influence of igneous rocks.[1]

Conglomerates are rarely met with in the Malmesbury beds. Some conglomerates with quartz pebbles have been described from the neighbourhood of Saron and Honig Berg in the Tulbagh and Piquetberg divisions,[2] but it is uncertain whether they really belong to this series. Mr. Schwarz says of the Honig Berg outcrop: "There are conglomerates between the Table Mountain sandstone and the slates (Malmesbury beds), apparently conformable to the former and unconformable to the latter, but the exposure is too small to say whether these relations hold good in reality". He remarks also that the conglomerates resemble those of Oudtshoorn; it is not unlikely that these beds will eventually prove to belong to the Cango series.

The true succession within the Malmesbury series has not been made out. They are nearly always found dipping at very high angles, and as they cover a large area, in places over thirty miles wide across the strike, it is certain that they must be intensely folded, and therefore repeated by folding, so that a much smaller thickness of rock is present than would seem to be the case. The country occupied by these beds is rather flat and has a regular rainfall, and the ground is well covered with soil and vegetation; in consequence outcrops are not very abundant, and years of detailed work will probably be required before the true structure of

[1] Examples of such an occurrence of ottrelite-schist in the Transvaal are given by Götz (85), p. 158.

[2] E. H. L. Schwarz, *Geol. Comm.* for 1898, pp. 27, 28.

the Pre-Cape rocks between the Peninsula and Piquetberg can be ascertained.

Veins of quartz are abundant in the Malmesbury beds, and at places they have been prospected for gold, without gratifying results.

The general strike of the rocks classed in this series is to the west of north in the western part of the Colony, approximately parallel to the trend of the Cederbergen and the other ranges in the west, which were formed chiefly after the deposition of the Ecca series; but in the south, between Worcester and Swellendam, in Bredasdorp, Mossel Bay, and George, the strike of the Malmesbury beds is on the whole nearly east and west, roughly parallel to the great southern mountain ranges. This change of strike in the Malmesbury beds may perhaps to a very small extent be due to the forces which produced the folds in the overlying rocks; but as the dip of the lower beds is generally far higher than the dips observed in the unconformably overlying rocks, it is impossible to thus account fully for the change in the direction of strike of the Malmesbury beds as they are followed eastwards. It is certain that these rocks were folded almost as much as we now see them before the deposition of the Cape formation, and the general parallelism between the two systems of folds, older and younger than the Cape formation, points to the repetition of the folding along the same lines at a great interval of time.

The Malmesbury beds have been invaded by igneous rocks of both acid and basic compositions. The acid

series, granite, gneiss, and allied rocks, is by far the more important. The masses of granite and gneiss are elongated in form, and lie with their longer axes parallel to the strike of the sedimentary rocks. They form the highest ground in the Pre-Cape area, with the exception of the outliers of Table Mountain sandstone. The largest granite area is that which stretches from St. Helena Bay south-south-east to Klein Dassen Berg, a distance of seventy miles, and the highest points reached by the granite are Kapoc Berg and Contre Berg, both over 1,500 feet above the sea. Saldanha Bay is a deep inlet in this mass of granite. On the western edge of the granite, along the shore near Paternoster, Danger, and Saldanha Bays, large inclusions of slate are frequently seen in the igneous rock, indicating the proximity of the Malmesbury beds; the edge of the intrusion is probably not far to the west of the present coast line.

Many varieties of granitic rock are found in this great area. The most abundant perhaps is a two mica (*i.e.* with both black and white mica) granite with orthoclase as the chief felspar. Tourmaline is often present in the rock near Darling. Every gradation between a normal granite and a gneiss, in which the foliation structure can be seen in even a small fragment, can be found; the massive granite is seen in the interior of the area and the foliated rock near the periphery, but this rule is not without many exceptions. There is no general difference in mineralogical composition between the granite and gneiss; the structural characters which separate the gneiss from the granite seem to have been given to the rock during its consolidation, for the gneiss

does not show evidence of a great amount of crushing or rearrangement of its component minerals after it solidified. The foliation planes lie in the same direction as the strike and cleavage of the sedimentary rocks in the neighbourhood; a similar direction is at places observed in the arrangement of the large porphyritic crystals of orthoclase that are occasionally found in great numbers in the massive granite, which shows no other parallel structure. There is no evidence of a difference in age between the granite and gneiss, and the gradual coming in of the gneissose structure as the area is traversed in various directions points to the whole mass being the product of one period of igneous activity.

Large and small veins or dyke-like bodies of micro-granite and quartz-porphyry with a micro-granitic base are found towards the edge of the area in many places. Near Hoetjes Bay the quartz-porphyries are especially abundant. Near Darling a mass of quartz-porphyry has a well-developed parallel structure, and may be considered to bear the same relation to the massive quartz-porphyry as the gneiss does to the granite.

In the hills to the south and west of Darling there are some remarkable rocks associated with the granite and gneiss. Colourless augite, plagioclase, and sphene are added to the usual constituents of the granite, and the mica is practically absent; the structure is that known as granulitic, the various minerals occurring in grains of a more uniform size than is the case with granite. These rocks often show a parallel structure but have not the foliated or schistose planes seen in the

gneiss. The nature and origin of the granulites of Darling are as yet unexplained, as is also their exact relationship to the surrounding granite and gneiss.

A few miles east of the southern end of the great mass of granitic rock just described is the irregularly shaped area of granite on which the town of Malmesbury is built. At the south end of this mass is the rugged mountain called Paarde Berg. The granite area is about twenty miles long and six wide, and lies in the direction of strike of the Malmesbury beds. The rock is much less varied in this area than in the larger mass to the west, and is mainly a rather coarse biotite-granite with porphyritic orthoclase, but fine grained granite composed of the same minerals, and coarse pegmatites are not infrequent. There seems to be no gneiss in this area.

South-east of Paarde Berg is the Paarl Mountain with the well-known group of smooth, naked granite crags on the summit. The most abundant rock in the Paarl Mountain is a biotite-granite. Dykes of quartz-porphyry in continuity with the main mass of granite traverse the surrounding slates along their strike. No gneiss has been observed in this mass.

On the east side of the Berg River between Wellington and Paarl is a long, narrow area of granite overlain by the sandstones (Table Mountain series) of the Klein Drakensteins. Both this granite and the Paarl Mountain rock have a more northerly direction than the other intrusions, and a corresponding change of strike is noticed in the Malmesbury beds of the neighbourhood.

South of the Paarl and Drakenstein granite areas is

the somewhat irregularly shaped mass of Pniel and Stellenbosch, with which are nearly connected those of French Hoek on the east, and of the Bottelary and Helderberg to the west. Gneiss enters largely into the constitution of those bodies of granitic rock, and, as in the case of the great intrusion on the Saldanha Bay coast, there is no evidence here that the intrusion of the foliated rock was of later or earlier date than the massive granite. In places, such as certain parts of the mountain slopes on the left bank of the Jonker's Hoek stream, the gneiss has been crushed along planes parallel with the direction of the dominant structural lines in the neigbourhood, the cleavage and strike of the slates, and the foliation planes of the gneiss; the crushing occasionally resulted in the production of a rock more like a gritty schist than a gneiss, but this extreme stage is connected with the uncrushed rock through breccias of different degrees of coarseness. The breccias were evidently formed in their present position by the breaking up of the gneiss, so that large and small subangular fragments of gneiss, and of its larger component minerals, are embedded in a fine-grained matrix. The fine-grained schistose rock is a true mylonite.[1]

The granites of the Paarl and Stellenbosch districts contain a fair amount of microcline, a variety of felspar which is rare in the Saldanha Bay and Darling area,

[1] Mylonite is the name giving by Professor Lapworth to crushed rocks with a parallel structure, in which all traces of the original structure of the parent rock may have disappeared (Lapworth, *Introductory Text-book of Geology*, p. 107).

although it seems to be the chief felspathic constituent of the granites in the northern and north-western parts of the Colony. On the south-west edge of the Bottelary granite cassiterite or tin-stone occurs in a gneissose muscovite granite together with tourmaline; wolframite has been found in the same neighbourhood.

Near Somerset West there are two masses of granite; the smaller one, Schaapen Berg, just east of the village, contains some interesting varieties of rock. The main mass of the intrusion is a biotite-granite with little muscovite, but the muscovite is very abundant in certain places and the felspar decreases in amount, and may disappear completely, so that the rock becomes a greisen, or quartz-muscovite rock. In other parts tourmaline is extremely abundant, sometimes giving rise to schorl rock, composed of tourmaline and quartz only. At other places andalusite, showing a beautiful pink tint under the microscope, forms a large part of a rock composed of quartz, tourmaline, muscovite, andalusite, and apatite.

The granite underlying a great part of the sandstone of Table Mountain and the other mountains of the Peninsula has been described by many previous writers. Professor E. Cohen [1] of Greifswald has described in detail the granite and the altered clay-slate near it, from the immediate neighbourhood of Cape Town; he was the first to record pinite, an alteration product of cordierite, in the biotite-granite there.

The contact of the granite and clay-slate at Sea

[1] Cohen (74).

Point and in the Platte Klip ravine have long attracted considerable attention. Playfair,[1] the enthusiastic disciple of James Hutton,[2] edited a description of the two localities written by Basil Hall in 1813. Playfair drew fresh support for Hutton's theory of the relationship of granite to the surrounding sedimentary rocks from Hall's letters and sketches. Clarke Abel[3] a few years later wrote a very accurate account of the same spots, and his conclusions are sounder than those of Hall, who regarded the elevation of the sandstones of the Peninsula as due to the rising up of the granite.

On the beach at Sea Point the junction of the two rocks is an extremely interesting one. The slates have been thoroughly permeated by the fluid granite, and have a shredded structure with granite lying between the slightly bent shreds of slate. Large orthoclase crystals, in every way similar to those in the porphyritic granite, have been formed in the lenticular areas between the laminæ of slate.

Small areas of granite intrusive in the Malmesbury beds are known in the south of Caledon, in the Hemel en Aarde and Zondag's Kloof valleys, and again in the western part of Bredasdorp.

[1] Playfair (13).

[2] Hutton, the leader of the old school of Vulcanists who insisted on the igneous origin of such rocks as granite and basalt, in opposition to the Neptunists, headed by Werner, who regarded these rocks as precipitates from the primæval ocean, rendered an even greater service to Geology by searching for explanations of geological phenomena in the everyday events on shore and land. His teachings in this respect had evidently been somewhat lost on Dr. Abel, who remarks that the Lion's Head must have been violently torn from Table Mountain.

[3] Clarke Abel (18).

In the narrow strip of Malmesbury beds north of the Worcester fault there are at least three granitic intrusions, all of which have been considerably affected by earth movements since their intrusion, and to some extent probably by movements during their consolidation. There is an abundance of phyllite-gneiss, a rock looking very like a highly micaceous clay-slate with "eyes" and thin strings of obviously igneous material, composed of quartz, orthoclase and mica. The orthoclase crystals often form the "eyes" with little other granite material in the same lenticular area. The largest mass of granite forms the high ridge just west of Robertson.

The last granite area in the south of the Colony that must be mentioned is that of George, a mass very variable in composition, at least thirty miles long from east to west, and from four to eight miles wide. It contains both muscovite- and biotite-granites with tourmaline and fluor; gneissose rocks also occur in the district.

The granite has in every case produced considerable mineralogical changes in the surrounding rocks. The result varies considerably in amount and nature, depending chiefly upon the character of the rock invaded. Highly quartzitic rocks are the least affected, and the alteration seems to increase with the clay content of the original slate. Up to the present time no metamorphosed calcareous rocks (except the marbles or crystallised limestones) have been noticed in the southern part of the Colony. The clay-slates become highly micaceous near the granite; sometimes, as in several places east of

the Darling granite and in the George district, they become typical mica-schists, rocks which glisten owing to the innumerable flakes of pale mica arranged parallel to one another, the other important constituent is quartz. At Zwart River Bridge, in George, a magnificent section of chiastolite-schist, a rock composed of chiastolite, mica, and quartz, can be seen; the crystals of chiastolite are often over two inches long. The chiastolite-schist is found within a few yards of a remarkably coarse two-mica granite, which also contains tourmaline.

Near the Cape Town, the Paarl, Stellenbosch and Somerset West granites the clay-slates become spotted at about 300 yards from the contact; and the spots are found in thin sections of the rock to be clear areas amidst the general mass rendered brownish in colour by the development of minute flakes of red-brown mica. The clear spots are composed of very minute crystalline grains of a mineral which has not been determined. Minute grains of felspar, recognisable by their twinning, have been developed in the spotted rocks, but they are not abundant.

At several places in the south-western districts igneous rocks of more basic composition than granite occur as dykes in the Malmesbury beds and in the granite. The dolerite dykes near Cape Town have been described in detail by Cohen[1]; they consist of augite, plagioclase and magnetite. These rocks differ in some respects from the average type of dolerite met with in the great

[1] Cohen (74), p. 10, etc., in the separate copies.

central basin of the Colony, the third of the three regions into which we divided the country. Although some of the Karroo dolerites contain no olivine, that mineral is very often present in them, and the rocks generally have an ophitic structure. In the dolerites of the Peninsula and Somerset West there is no olivine, but the felspar is rarely enclosed by the augite, in other words, they are seldom ophitic in structure. These differences are rather slight, especially when it is remembered that they are based upon a comparison between about a dozen representatives of the southern dykes and over a hundred of the Karroo dolerites, taken from an immense area. The analyses published by Cohen of one of the Cape Town dykes and of thirteen of the Karroo rocks, show that the former is very similar in composition to the latter. The Karroo dolerite is generally less altered than the southern dykes.

The differences between the two sets of dolerites is so slight, in fact, that they might well be considered to belong to one and the same group of intrusions. The age of the southern dykes is certainly younger than that of the granite and Malmesbury beds; as they have not been observed traversing the Table Mountain series they are generally looked upon as older than that rock, but it is possible, on the supposition that they belong to the same series as the Karroo dolerites, that they were not able to break through the horizontally overlying sandstones after reaching the limit of the granite or slate. The junction of a dolerite dyke and the sandstone has not yet been clearly seen, nor have pebbles of dolerite been found in the sandstone, so

the question of the relative ages of the two rocks is still an open one.[1]

Some interesting rocks, which may be called diorites and quartz-diorites, form rather limited dyke-like masses in the granites of the Malmesbury district. At Klein Paarde Berg there is a broad dyke about a mile long, composed of hornblende, felspar, mica, quartz, magnetite, apatite and zircon. It is a holocrystalline rock, and the hornblende often encloses the felspar crystals, so as to give the rock a partly ophitic structure; some large crystals of mica (biotite) behave in the same way. Most of the felspar belongs to the oligoclase series of the plagioclases, but there are patches of a very much altered felspar, strongly contrasted to the clear crystals of plagioclase, which are very probably orthoclase. Quartz is present in considerable quantity, filling up the spaces between the other minerals. The rock is little altered as a whole, but some of the mica is replaced by chlorite, and some epidote, derived from the alteration of other constituents, is present. Another variety of diorite in this neighbourhood contains the same minerals as the one just described, but monoclinic pyroxene, with the characteristic diallage structure, is present in considerable quantity, forming in thin sections ophitic plates enclosing felspar. The pyroxene sometimes forms complicated

[1] Since this was written it has come to the notice of the writer that Mr. T. Stewart, M.I.C.E., exhibited a piece of dolerite from a dyke in the sandstone of Table Mountain at a meeting of the S. A. Phil. Soc. in 1895. Lately two such dykes have been mapped by the survey in the T. M. S. of the Peninsula; compare with the dykes in the same rock of the Bokkeveld Mountain and Pondoland.

intergrowths with the hornblende and also occurs in the centre of large hornblende crystals; in such cases one set of prism cleavages is common to both minerals.

In the gneiss of Klein Dassen Berg there is a dioritic dyke intruded parallel with the foliation planes of the gneiss. The rock of this dyke is rather different from the Klein Paarde Berg rock, in that the constituent minerals, plagioclase, hornblende, and quartz form nearly equal-sized grains, and none of them have any proper crystal faces; the structure is typically granulitic. At Yzer Fontein Point is a large mass of hornblendic rock, coarsely crystalline, with a banded structure; some thick layers are formed entirely of green hornblende, and others, usually thinner, have a fair proportion of plagioclase in them. These dioritic rocks seem to be confined to the Malmesbury district.

In the George granite there are some dykes of hornblende-schist, composed of long and rather fibrous crystals of green hornblende, arranged parallel to one another, with a smaller quantity of quartz and plagioclase grains between them, and a still smaller amount of epidote. This rock is evidently a highly altered basic dyke, but there is as yet little evidence of its original nature.

The Cango Series.

In the Cango district, the country near the northern boundary of Oudtshoorn on the southern flank of the Zwartebergen, there is a group of sedimentary rocks older than the Table Mountain sandstone, and therefore usually classed with the Malmesbury beds. There are, however, so many peculiarities in the Cango rocks

which separate them from the bulk of the Pre-Cape rocks of the Malmesbury and other divisions in the south-west of the Colony, that it is advisable to distinguish them by some other name; the term Cango conglomerate[1] has already been used for a prominent band of rock in the series, and it will be convenient to call the whole group the Cango series.

The series forms a lenticular area about seventy miles in length from east to west, from near Amalienstein (Ladismith) to some few miles east of Meiring's Poort, and at the most about nine miles wide. The Table Mountain series bounds the area on the north, and the southern limit is formed by the conglomerates of the Uitenhage series between Meiring's Poort and Calitzdorp, a distance of fifty miles; west of Calitzdorp the sandstones of the Table Mountain series overlie the Cango beds along their southern limit, and farther west again the sandstone is faulted down against them, the fault being so formed that its throw increases and brings the Bokkeveld beds into contact with the Cango; some miles east of Meiring's Poort, also, the Bokkeveld beds are faulted down against the Pre-Cape rocks, and there can be no doubt that this fault, exactly comparable to the Worcester fault, is continued westwards under the covering of Uitenhage beds at least as far as Calitzdorp, and is probably continuous with that already mentioned west of the village (see Figs. 6 and 7).

Along almost the whole length of the northern boundary the Table Mountain series dips at a high angle

[1] *Geol. Comm.* (98), pp. 7, 68, etc.

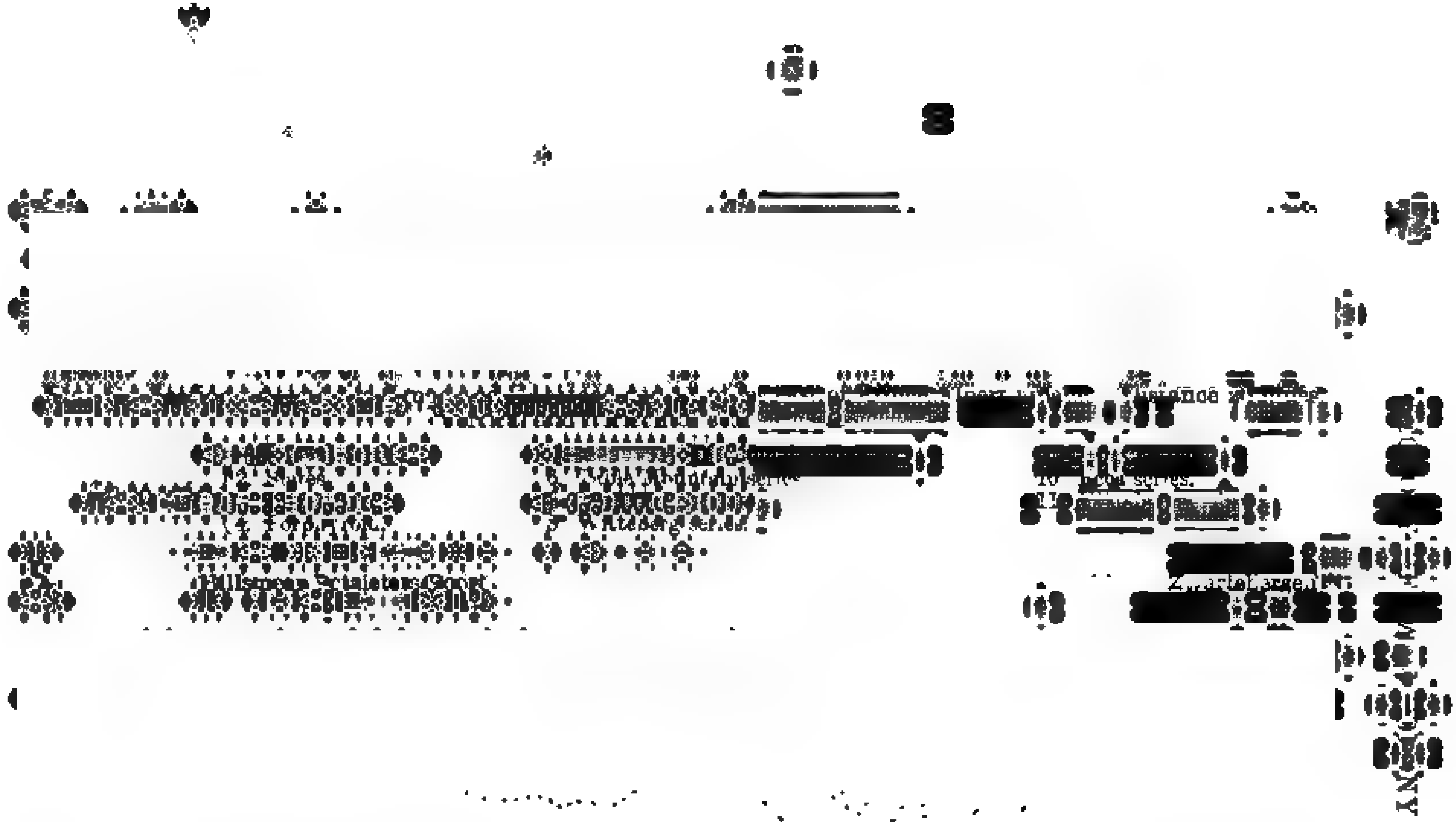


Fig. 7.—Section through the Cango from Poigieter's Poort to the Zwartebergen. Distance 20 miles. Vertical scale $\frac{1}{16}$ in. to 1,000 feet.

Cango series:
1. Quartzites.
2. Conglomerate.
3. Slates.
4. Limestone.

5. Intrusive dolerite (altered).
6. Table Mountain series.
7. Uitenhage series.

southwards below the Cango beds, and the latter dip at approximately the same angle in a southerly direction. At the south end of the Gamka Poort, where there is one of the very few clean cut sections of the junction of the two formations, there appears to be a conformable passage between the two. At other spots, however, such as the south end of Meiring's Poort, the Table Mountain series dips steeply to the north, and lies unconformably upon the older beds which dip at a still higher angle to the south; the contact of different members of the Cango beds with the base of the Table Mountain series at various points corroborates the evidence of the Meiring's Poort section, so there is no doubt that the junction is an unconformable one. It is very probable that the Table Mountain sandstone was deposited upon the then nearly horizontal Cango beds, which had suffered some denudation, so that the base of the former group rested upon different horizons of the latter series at different localities. During the great earth movements that produced the Zwartebergen the two series were together folded and inverted, so that at places the older beds appear to overlie the younger conformably.

The Cango beds usually have high southerly dips, but in the neighbourhood of Kruis River, west of the road up the Zwartberg Pass, the strike is north-east. The top or bottom of a fold is occasionally seen; this indicates that the series is thrown into isoclinal folds, and that the observed great thickness of southerly dipping beds is really due to the repeated folding of a much smaller thickness of rocks. The true succession of the

members of the series is rather uncertain, and the bottom has not been found.

The series consists of conglomerates, quartz-felspar grits, quartzites, slates and limestones, in all a very considerable thickness of rock, not under 10,000 feet. These are accompanied by intrusive rocks of the nature of diabase or altered dolerite (see Fig. 7). The conglomerates lie next to the Table Mountain sandstone in the western part of the area; in the central portion the limestone lies in a similar position, elsewhere slates or quartzites are in contact with the sandstone. At the Gamka Poort thick bands of conglomerate are in contact with the Table Mountain series. There are several varieties of conglomerate in the Cango beds, differing chiefly in the nature of their contained pebbles and in the amount of shearing they have undergone. In the west, on the hills north of the Ladismith Road near Vaartwell, the conglomerate has been sheared to such an extent that the original forms of the pebbles (slaty rocks and vein-quartz) are no longer recognisable, and in many cases the exact limit between pebble and matrix is indefinite. Farther east the conglomerates are more normal in character, but the effects of shearing are still very evident. In Schoeman's Poort, where excellent sections through the conglomerate are exposed by the roadside, large pebbles or boulders of granite and diabase are seen in it. The occurrence of these is interesting, as it proves the Cango beds to be later in age than some rocks—possibly the Malmesbury beds—which were invaded by granite and diabase before they furnished sediments for the building up of the Cango

beds. So far as is known at present there is no unconformity at the base of the conglomerates of which there are at least two bands, and although in the Grobbelaar's Valley, and other places farther west, slates are seen on either side of the steeply inclined conglomerate, it is even difficult to decide which is the top and which the bottom of that rock. It may be that the bottom is nowhere seen, and the slates on either flank of the conglomerate overlie the latter.

A remarkable group of beds, formed chiefly of various sized fragments of quartz and felspar, extends for a considerable distance along the strike of the Cango series, half a mile north of the conglomerate between Grobbelaar's River and Matje's River. The felspar occurs in fragments of such size and form that in places the rock has the appearance of a porphyritic granite. When examined under the microscope in thin sections the quartz and felspar are seen to be broken crystals, although the crystalline form of the quartz is occasionally seen. The felspar is mostly microcline, but albite is frequently, and orthoclase occasionally, met with. These minerals are enclosed in a ground mass chiefly composed of small grains of quartz and minute flakes of sericite, a pale micaceous mineral; small flakes of brown mica are sometimes found taking the place of the sericite. The mica forms a thin casing round the large grains of quartz and felspar, and the two latter minerals are often seen almost in contact with a very thin film of sericite between them. The sericite occurs in this rock in the same manner as in many gneisses and conglomerates

that have been subjected to great pressures in the earth's crust. In some localities the rock shows a distinct schistosity, and in thin sections the large quartz fragments are seen to be elongated in the plane of schistosity, and have patches of interlocking grains of quartz at their two ends, as if the material had been removed from the sides of the fragments and deposited at the ends. The minute sericite flakes lie in one direction, along the planes of schistosity. The quartz-felspar rock of the Cango is very like the so-called porphyroids, and appears to have been a sedimentary rock composed chiefly of fragments of quartz and felspar, in which the micaceous minerals have been developed by pressure. In places bedding planes are distinctly seen, and varieties intermediate between the porphyroid and ordinary grits with few felspar fragments have been found between the main band of porphyroid and the southern slope of the Zwartebergen. In the valley from which the Cango caves are entered three beds of conglomerate, a quartz-felspar grit with rounded boulders and pebbles of granite, mica schist, quartzite, crystalline limestone, and vein quartz, are seen in the stream bed below the caves. The transitional varieties and the conglomerates certainly support the conclusion that the porphyroid of the Cango is a sedimentary rock, but whether it was formed by debris derived from a granitic region, or whether it is of the nature of a volcanic tuff is not clear; the abundance of microcline in the porphyroid and the absence of lavas from the district favour the former supposition.

There are many bands of limestone in the Cango

beds, sometimes of great thickness; they are lenticular in form, but to what extent this is due to folding has not been determined. The chief limestone band is that which is in contact with the sandstones of the Zwartebergen near the south end of the Zwartberg Pass. It extends for some fifteen miles eastwards, and in it are the famous Cango Caves.[1] The cave, at least that part known in 1897, is nearly 750 yards long, and is probably of still greater extent. The explored portion of this cave lies in a nearly straight line. There can be no doubt that the cave has been formed by the solution of the limestone, aided by the breaking away of the roof and sides and the removal of the debris by running water. The cave has not been sufficiently explored to explain its formation fully, and the level of the floor at various points is not known. The floor itself is at least partly made of debris cemented with calcareous tufa and stalagmite. The walls and roof of the cave, in those parts which have not been disfigured by the smoke of candles, are very beautiful, owing to the number, form, and brilliance of the stalactites attached to them. Other caves, the entrance to which is often on the face of cliffs along the sides of the valleys, await exploration in the Cango district. The band of limestone in which the great cave is situated is about 1,800 feet thick, but when traced to the east or west it gradually becomes thinner. The limestone in the Cango beds is crystalline and dark grey in colour and usually con-

[1] For a description of the cave see G. S. C. Corstorphine, *Ann. Rep.* (96), p. 34; a plan of the cave by H. M. Luttman Johnson accompanies the description.

tains some magnesium carbonate, but in some localities it is sufficiently pure to yield good lime. Occasionally oolitic beds are met with, and when examined under the microscope these are found to contain organic remains, although no determinable shell has been seen. These are the only traces of fossils hitherto found in the Cango series.

Slates and fine quartzitic grits form a great part of the series. The slates are irregularly cleaved, and no rock of use for roofing has been found amongst them.

The intrusive rocks in the Cango district are nearly all altered to such an extent that the original minerals composing them have been replaced by others. At present the chief components are the fibrous variety of hornblende called uralite, green hornblende, augite, epidote, chlorite, felspar, quartz, calcite, sericite, magnetite, apatite, and brown mica. The greater number of the dykes were originally dolerites without olivine, made up principally of augite and felspar; some contained much hornblende which still remains in the rock. The augite has been mostly altered to uralite, but kernels of the former mineral are still left within the patches of fibrous hornblende. The rock has often an ophitic structure, the felspar crystals lying partly or wholly within the patches of fibrous hornblende derived from augite. The calcite is sometimes sufficiently abundant in the rock to cause it to effervesce like an impure limestone when a drop of dilute acid is put on it. The calcite is often seen to partly replace the large crystals of felspar, but most of it occurs in the ground

mass of the rock. It is to be looked upon as one product of decomposition of the lime-soda felspar which once formed a large part of the rock. Epidote is often a very abundant constituent, and is probably derived from the lime-soda felspar. Little of the original felspar remains, although the outlines of that which has been altered to other minerals can usually be found in thin sections, and in the case of porphyritic crystals the pseudomorphs are easily seen by the naked eye.

Dykes of these altered rocks are fairly numerous in all parts of the Cango district; they are usually only a few feet in width, but are traceable for considerable distances. In the valley of the Nels River in the eastern Cango there are fifteen dykes in the slates within a distance of two miles, all traversing the rocks parallel with or at a small angle to their strike. In the valley of the river which leaves the Cango through Coetzee's Poort three dykes are seen, the northernmost one is six feet thick, the second over 100 feet, and the southernmost is of much greater size and makes an outcrop nearly a mile in width. This great intrusive mass has been traced for twelve miles along the southern edge of the Cango between Coetzee's and Potgieter's Poorts, forming rather prominent deep red hills (see Fig. 7). It is a peculiar type of rock, with much hornblende forming ophitic plates enclosing the felspar, the hornblende is colourless and seems to have been formed from augite. The Gamka River, above the Ladismith Road, crosses a dyke of peculiar diabase, in which the rather long crystals of felspar form radiating star-shaped bundles. Beyond a marked hardening of the slates or

grits in contact with the thicker dykes, there is little alteration in the sedimentary rocks near them.

It has already been said that some rocks resembling parts of the Cango beds occur in the neighbourhood of Saron and Honig Berg, perhaps overlying the Malmesbury beds unconformably. There is no evidence in the Cango bearing directly upon the correlation of the distant outcrops, as no beds which can be determined as belonging to the Malmesbury series have been found in the district. The presence of granite boulders in the Cango conglomerates may indicate the later age of those conglomerates as compared with the granite intrusions of the so-called Malmesbury beds of the southern part of the Colony, George, and Mossel Bay. The quartz-felspar grits may have had a similar origin. In the absence of more reliable evidence this is of some worth.[1] There are some points of resemblance to the Cango beds in the Ibiquas series north-east of Van Rhyn's Dorp to be noticed hereafter. At present it is useless to attempt to compare the ages of the Cango beds and the sedimentary rocks of Prieska and Griqualand West. All that can be said is that they are both older than the Cape formation.

The Ibiquas Series.

In the west of Calvinia and east of Van Rhyn's Dorp there is an area of conglomerates, grits, slates, and sandstones lying unconformably below the Table Mountain series of the Bokkeveld Mountain, and so

[1] See Corstorphine, *Geol. Comm.* (98), p. 12.

distinct from the Malmesbury beds of the west and south of Van Rhyn's Dorp, upon which they appear to rest unconformably, that they have been placed in a separate group under the name Ibiquas beds.[1] These beds occupy the greater part of the valley of the Doorn River behind the Stink Fontein Poort, where they can be well seen. The beds are considerably folded, but on the whole they dip eastwards, so that the base of the series lies on the western side of the area. The lower part of the series consists of conglomerates and grits, evidently derived from a granitic area, as granite and quartz-porphyry pebbles are conspicuous amongst the contents of the conglomerates, and the grits contain much quartz and felspar; sometimes these two minerals are so abundant as to make the rock an arkose. There is thus a resemblance in these rocks to the quartz-felspar grits of the Cango, but the porphyroids of the Cango are as yet unknown in the Ibiquas series.

The Ibiquas beds, like the Cango, have not (so far as is known) been invaded by granite, but only contain fragments of that rock in the conglomerates. The Cango beds are not known to rest unconformably upon the Malmesbury series, but there is at least strong presumptive evidence that the Ibiquas lie discordantly upon the latter in Van Rhyn's Dorp. In each case there is a weaker discordance with the overlying Table Mountain series than exists at the junction between the latter and the Malmesbury beds. These points of similarity between the far separated Ibiquas and Cango

[1] *Geol. Comm.* (00), p. 25, etc.,

series suggest that they may belong to one and the same group of rocks, but until fossils are found in them the question cannot be settled.

Above the conglomerates and grits of the lower part of the series lie slates, sandy shales and sandstones, which rarely show distinct cleavage planes, such as are almost always seen in similar rocks in the Malmesbury beds. The shales and sandstones are met with on the steep escarpment of the Bokkeveld Mountain, and in the Doorn River Valley. They are rather like the shales and sandstones of the Bokkeveld beds, but the thick groups of sandstone beds, so characteristic of the latter, are not found in the Ibiquas series.

Ripple markings are extremely well preserved in many of the sandstones throughout the series, and point to the deposition of the beds in shallow water. Large tracks and castings of some worm-like animal are occasionally abundant, but these are the only fossils known from the series. The nature of the rocks seems very favourable for the preservation of organic remains, and they are more likely to yield recognisable fossils than any other Pre-Cape rocks in the south and west of the Colony. They are unfortunately situated in a district which is thinly populated and difficult to get at. The thickness of the Ibiquas beds must be very considerable; on the face of the Bokkeveld escarpment over 1,500 feet of these beds are exposed, but the base is some distance from the foot of the escarpment, and the highest beds visible lie about fifteen miles to the east, where they are covered by the Dwyka conglomerate. Although the beds are partly repeated by folding be-

... their whole

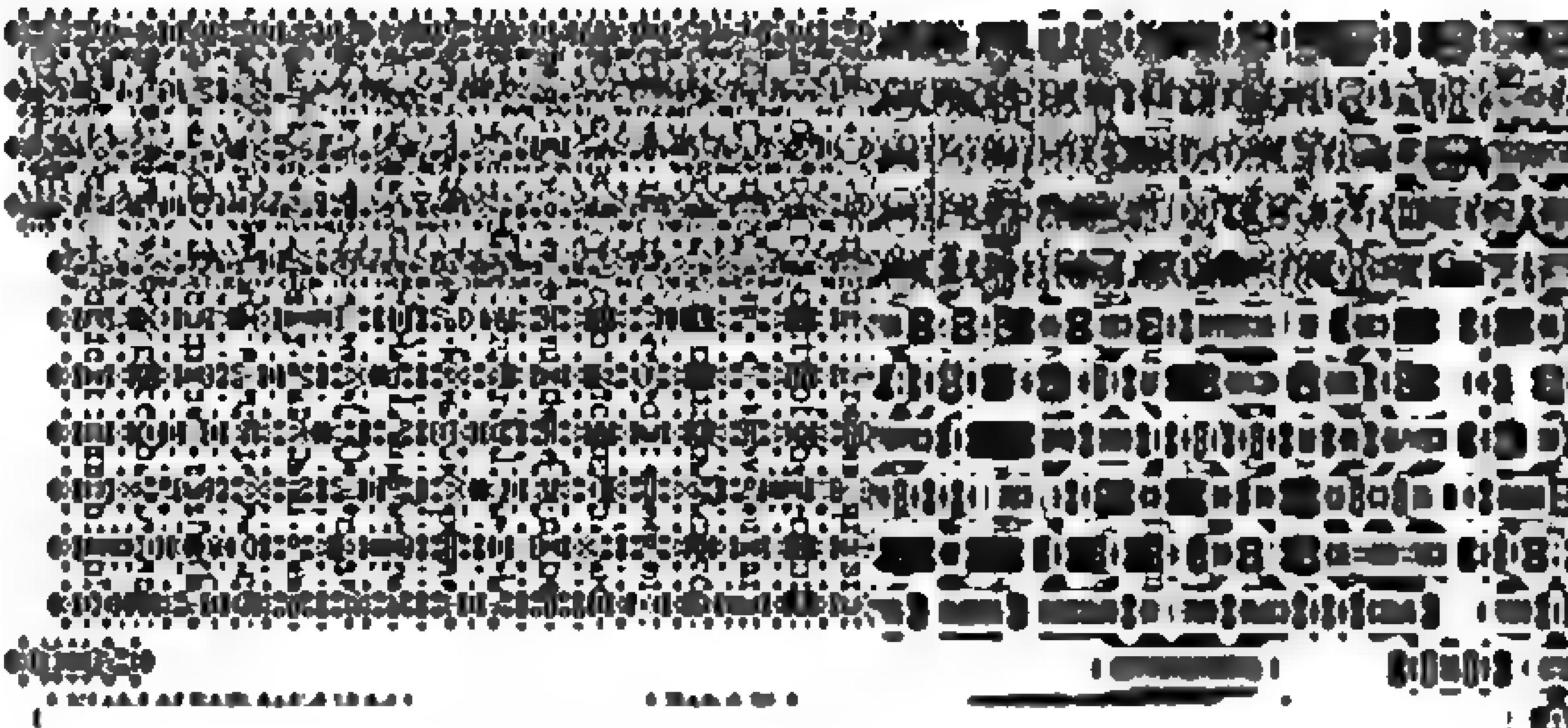


FIG. 8.—Section from the Van Rhyn's Dorp flats to the plateau above Louries Fontain. Distance 80 miles. Vertical scale $\frac{1}{10}$ in. to 1,000 feet.

1. Granite.
2. Ibiquas series.
3. Table Mountain sandstone.
4. Dwyka series.
5. Ecca series.
6. Intrusive dolerite.

The only intrusive rocks hitherto found in the Ibiquas beds are dykes of dolerite, evidently belonging to the same group of intrusions that form the sheets and dykes in the country occupied by the Karroo formation to the east and south-east.

The section in Fig. 8 illustrates the structure of the Ibiquas beds in the Doorn River Valley. The line of section is so chosen that it runs across the fault on Klomp Boomen, and also through the Dwyka conglomerate resting upon the Table Mountain sandstone of the Bokkeveld Mountain on the south-west, and upon the granite on the north-east of the Doorn River Valley; but if the section had been drawn along a line a few miles to the south of that chosen, the conglomerate would lie upon the Ibiquas beds.

Up to the present time the Ibiquas beds have not been found in the Malmesbury Division, but lately a group of comparatively unaltered shales and reddish sandstones has been noticed lying unconformably below the Table Mountain sandstone at two places on the Verloren Vley River in Piquetberg. The outcrops are on the farm Witte Drift within a few yards of the highly altered sericitic slates belonging to the Malmesbury beds. Although the actual contact of the shales and sandstones with the slates is obscured by alluvial deposits there is little room for doubt that the former rest unconformably upon the latter. These shales and sandstones may be regarded as part of the Ibiquas group, although there is no evidence from fossils to rely upon.

CHAPTER III.

THE PRE-CAPE ROCKS OF THE NORTH AND NORTH-WEST.

TURNING now from the southern and western districts to those lying north of the central basin of the Colony we find that no parallelism can at present be instituted between the rocks of the two areas, and the intervening country, composed probably to a great extent of granite and gneiss, is scarcely known from a geological point of view. The country lying between the Langebergen in the south end of Bushmanland and the Kaaing Bult, between Kenhardt and Prieska, including Bushmanland and the Kenhardt Division, has been traversed by Wyley and Dunn, but very slight accounts could be expected from rapid journeys through it, and they leave the connection between the better known rocks in Prieska and in Calvinia and Van Rhyn's Dorp quite unexplained. The geology of West Griqualand was described by the late G. W. Stow,[1] and in the map published with his paper the extension of some of the various rock groups south of the Orange River in the Prieska Division is roughly indicated. When the geological survey of the Prieska country was made in 1899[2] Stow's classification was found to hold good, so the various names used by

[1] Stow (73).

[2] *Geol. Comm.*, (99); the whole division has not yet been mapped.

him for the West Griqualand groups of rock were applied to the Prieska beds. There are several important points, however, which are not yet clear, and a vast amount of work still awaits the geological explorer in those regions. Stow's paper, one of the most important contributions to Colonial geology yet published, has suffered from a want of arrangement of the large array of facts contained in it, but it should be read by all who are interested in the north of the Colony.

Prieska and Griqualand West have an additional interest from the circumstance that some of the rock groups which occur there are very probably continuous with the formations overlying the Witwatersrand beds of the Transvaal (Cape system of Dr. Molengraaff). This part of the subject will be returned to after the structure of the country and the formations have been described.

Granite and gneiss form most of the lower lying part of Griqualand West and Prieska, rarely rising far above the generally sandy ground in hills or "tors" as the granitic rocks in Bushmanland and in the south-western districts do. The higher ground is composed of sedimentary rocks greatly altered from their original condition both by pressure and by the intrusion of the granitic rocks. The chief hill ranges are: (1) the Campbell Rand, or Kaap Plateau, trending south-west through Griqualand West, and having no continuation in Prieska; (2) the Asbestos Mountains, parallel to the Campbell Rand on the western side, turning through almost a right angle where cut through by the Orange River and continued in Prieska by the Doornbergen trending south-east; (3) the ranges of Matsáp and the Lange-

bergen, with a south-south-west trend continued south of the rivers in Ezel Rand; and (4) the Schurfteberg trending south on the north bank of the river, and continued at first in a similar direction but farther south by the Brakbosch Poort range trending south-east, parallel to the Doornbergen, in Prieska. There are many smaller groups of hills parallel to the larger ranges and rising to moderate heights above the granitic plains which surround them.

It was stated in the introductory chapter that the hill ranges are parallel with the strike of the rocks composing them; the change in direction of the strike of the rocks indicated by the bending of the hill ranges near the Orange River is a fact of the greatest importance in the structure of that part of the Colony.

The sedimentary rocks of these districts are divided up into the following groups from above downwards:—

4. Matsáp series.
3. Griqua Town series.
2. Campbell Rand series.
1. 'Keis series.

The 'Keis Series.

The oldest rocks in Prieska are the quartzites and mica-schists of the 'Keis series, which form a long range or rather group of ranges of hills stretching from the Schurfteberg on the north of the river to Jonker Water, ninety miles to the south-south-east, where they disappear under the Dwyka conglomerate. Inliers still farther south prove that they extend a few miles beyond the end of the main mass, but how far they stretch beneath the covering of the Karroo formation is un-

known. The dip of these rocks at the north end of the district is at high angles to the north-west, but on Ezel Klauw the dip changes to west and north-west, on Kaboom to west, and farther south still, from Brul Pan to Jonker Water the dip is west-south-west.

The quartzites are remarkably uniform in character, and have not been found to pass into conglomerate beds; they are light in colour and contain small flakes of mica. By the increase in the amount of mica there is a gradual passage into mica-schists very rich in mica. The more micaceous the mica-schist is the more readily it disintegrates, and it is difficult to obtain fresh specimens of the highly micaceous rock, even from the bottom of wells from 40 to 70 feet deep. This is a remarkable fact in such a dry country as Prieska, where those processes of disintegration which depend upon the presence of moisture are very much reduced. As a consequence of their friable nature the mica-schists occur chiefly in the valleys; they have in fact determined the positions of the minor valleys in the country occupied by the 'Keis series. The floors of the valleys are almost always deeply covered with sand derived from the rocks in the neighbourhood.

It has been found impossible to distinguish between the planes of bedding and those of schistosity in the mica-schist, and the same is the case with some of the quartzites belonging to the 'Keis series.

At Klein Modderfontein, on the north-east side of the outcrops of the 'Keis series, a rock similar to the highly micaceous schist, with the important addition of immense numbers of crystals of almandine garnet, occurs,

interbedded with the usual quartzites of the series. In parts of the garnet rock the mica disappears and the garnets are embedded in quartz, often stained with green copper compounds.

Along the greater part of their course the 'Keis beds are flanked on either side by granite or gneiss, and areas of these rocks also occur in the heart of the series at Kaboom, Brakbosch Poort, and probably other places. At Boschiesman's Berg and Van Wyk's Pan tongue-shaped masses of gneiss project into the series from the great granitic area. These tracts of igneous rock are elongated in the direction of the strike of the 'Keis beds, and the foliation and planes of schistosity of the two rocks are parallel. On Grenaat's Kop there is an inlier of 'Keis beds surrounded by the Dwyka conglomerate, and a comparatively narrow dyke of granite traverses the inlier in a direction at right angles to the strike of the latter. The Grenaat's Kop dyke is the only clear case of intrusion of the granite in the 'Keis series seen in the district. In other parts the contact of the igneous and sedimentary rocks has not been seen, owing to the thick covering of sand, and it would be possible to account for many of the facts observed on the supposition that the 'Keis series was deposited upon a floor of granite and that at some subsequent period the rocks were intensely folded, so that on the one hand ridges of gneissose granite were formed projecting into the quartzites and schists, and on the other steeply folded synclines of the sediments went down into the granite.

At many places in the granitic areas both east and west of the ridges of 'Keis hills there are isolated len-

ticular patches of highly metamorphosed rocks, mica-schists, and banded hornstone-like rocks with much epidote and quartz in them, bearing evidence of having been of sedimentary origin, as well as quartzites. These detached outcrops were probably once connected with the main area of the 'Keis beds. There are other masses of altered sedimentary rocks situated in the granite areas more like beds in the Griqua Town and Campbell Rand series, and it will be more convenient to give a further account of the relation of the granite and gneiss to the 'Keis series after these have been described.

Stow[1] described the occurrence of some "ancient schistose" rocks lying unconformably below the Campbell Rand series west of Campbell Town; they are quartzitic rocks with calcareous matter added by infiltration from the overlying beds. These older rocks are also marked on his map as being found north of Jonker Water in Prieska, but the outcrops at the latter place undoubtedly belong to the 'Keis beds. The "ancient schistose" rocks near Campbell Town seem, from Stow's account, to be similar to parts of the 'Keis series also, so it is not unlikely that there is direct evidence of the unconformable succession of the Campbell Rand to the 'Keis beds in West Griqualand. In Prieska no evidence on this point has been obtained, as the Campbell Rand beds hitherto recognised there are only found at some considerable distance from the older series.

A bed of limestone, presumably interbedded with the quartzites and mica-schists, has been found on the farm

[1] Stow (73), p. 619, and Pl. XXXIX., Fig. 4.

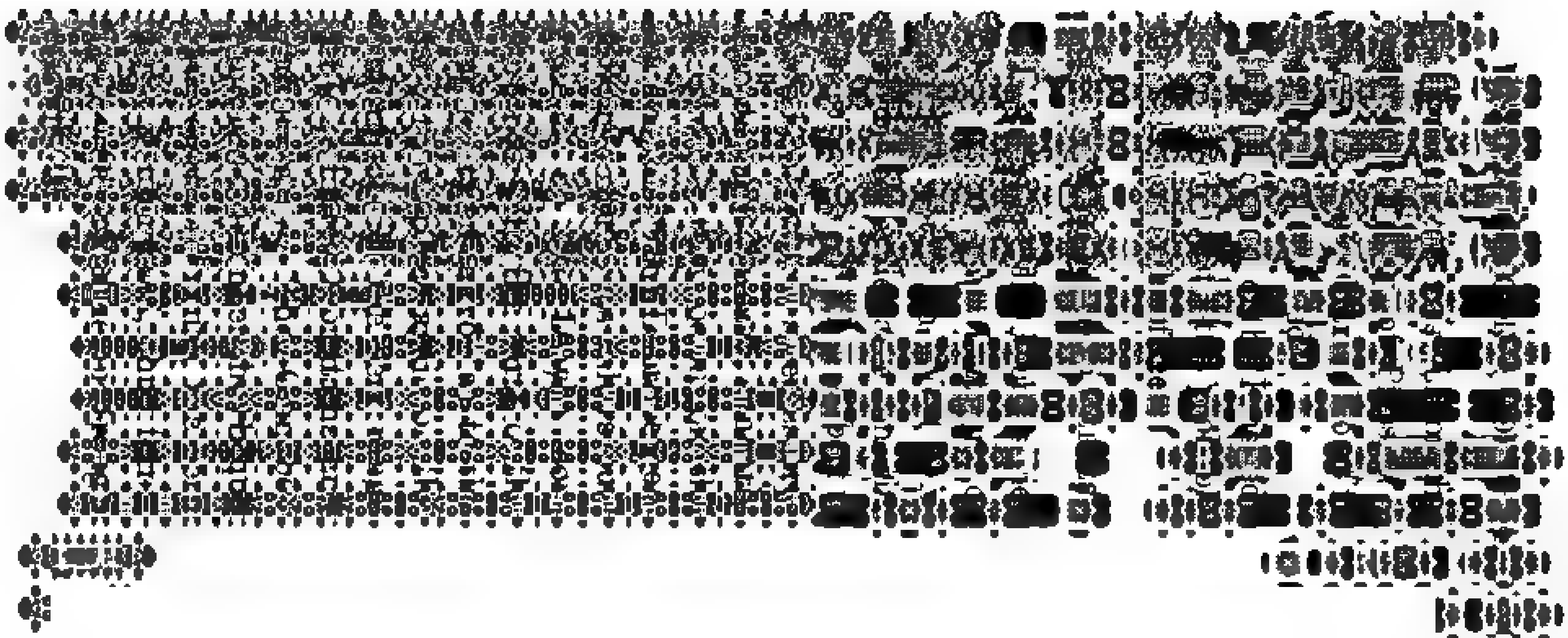


FIG. 9.—Section across the Prieska Division. Distance 28 miles. Vertical scale $\frac{1}{16}$ in. to 1,000 feet.

1. 'Keis series.
2. Quartzites } Campbell Rand series.
3. Limestones }
4. Griqua Town series.
5. Granite and gneiss.
6. Granulites.
7. Dwyka conglomerate.

The Campbell Rand beds consist of quartzites, micaceous schists, limestones and cherts. The true base of the series has not been recognised in Prieska, but it is almost invariably the case that the limestones are underlain by a considerable amount of quartzite, varying from 200 to 2,000 feet in thickness. At Zeekoe Baard in Prieska the quartzites are apparently conformably underlain by green slates, which have not been seen elsewhere in the series. The lowest beds of the series in the Kaap Plateau are limestones and quartzites, but there does not seem to be such a definite group of quartzites at or near the base in that district as there is in Prieska.

The quartzites in Prieska are of very much the same nature as those belonging to the 'Keis beds, but mica-schists are much less extensively developed than in the latter series.

The limestones are dark coloured and thoroughly crystalline, usually weathering with a peculiarly rough brown surface, a character that has led to the rock being known as Oliphant's Klip from its resemblance to an elephant's skin. The limestone often contains a certain percentage of magnesium carbonate, and is therefore a dolomitic limestone.

On the right bank of the Orange River, opposite Buis Valley, there are some fine vertical cliffs of the limestones rising straight out of the water for some distance along the river; the face of the cliff is indented as if by shallow caves, but there seem to be no caves of any noteworthy extent as there are in the Cango limestones and in the dolomitic limestones of the Transvaal, al-

though the latter very probably belong to the same series as the Prieska rock.

Thin layers of chert, often somewhat irregular and nodular, are very abundant in the limestones. Although several specimens have been carefully examined under the microscope for traces of organisms that have been found in rocks of this nature in many parts of the world, nothing obviously of organic origin has yet been seen in them. The chert is a very hard rock which breaks into pieces with sharp, splintery edges. The hardness of the chert made it a suitable one for the natives to use as rough cutting and scraping tools, but it seems to have been less used for such purposes than the jasper of the succeeding group of rocks. The beds and nodules of chert stand out from the general surface of the limestones in which they lie, owing to the more rapid solution of the limestone, and give rise in places to remarkably jagged and uneven surfaces.

No fossils have been recorded from the Campbell Rand beds; but of late years one has heard so many rumours and statements to the effect that they have been seen in more than one locality in West Griqualand, that the discovery of some recognisable forms may be confidently expected. Any such find will be of very great interest, for without fossils the age of the old rocks in the north can never be satisfactorily determined.

On the farm called Alicedale in Prieska, there is a band of crystalline limestone about fifty feet thick associated with mica-schist, quartzite, and magnetic quartzite, the latter is like some of the rocks belonging to the Griqua Town series; the beds dip vertically and

form a lenticular area surrounded by granite. The mica-schist contains coarse veins of pegmatitic granite with large plates of white mica. The limestone has a band of schistose rock in it with crystals of almandine garnet as much as two inches in diameter. The garnet seems to be a product of metamorphism due to the proximity of the granite. Whether the mica-schist belongs to the limestone and quartzitic group of the Campbell Rand group is not certain.

The limestone of Zeekoe Baard contains thin beds of red jasper, like some of the jaspers of the Griqua Town series, but the occurrence of jasper interbedded with the limestone strata seems to be more frequent to the north of the river than in the Prieska Division.

The maximum thickness of the Campbell Rand series is about 7,000 feet in Prieska, but towards the south-eastern part of the Doornbergen it disappears or gets very thin, a fact of which the true explanation has not been ascertained.

Some rather large masses of galena are met with near the base of the Campbell Rand beds on the western flank of the Doornbergen near their northern end. Curious veins of white quartz and pink orthoclase are found in the limestones at Zeekoe Baard.

The relationship of the Campbell Rand group to the overlying Griqua Town series is best seen between Nauga and Buis Valley, where they have undergone less disturbance than farther to the south-east. The structure of this part of the Doornbergen is broadly a double syncline, and is represented in Fig. 9. The limestones dip under the Griqua Town beds on Kalk

Fontein, reappear in a narrow anticline on that farm, and pass under the higher beds again to the east, and rise to form the banks of the Orange River on Buis Valley. To the south-east, along the south-western flank of the hills, the beds are frequently overturned, so that the Griqua Town beds dip at high angles under the limestones, and these in their turn under the quartzites of the base of the Campbell Rand group.

The Griqua Town Series.

The Griqua Town series forms the rugged hilly country that stretches sixty-five miles south-eastwards from the Orange River at Kameel Puts to Doornberg's Fontein, generally known as the Doornbergen. To the north of the river the series passes north-eastwards in the Asbestos Mountains, and extends far into Bechuanaland, probably reaching the borders of the Transvaal, but nothing definite is yet known of that part of the country.

The series consists of peculiarly heavy green slaty rocks with quartzites and jaspers containing large quantities of magnetite. Much of the rock is banded, the thin layers having slightly different colours of which deep red, bright red, brown and black are the most usual. The black layers are almost entirely composed of minute crystals and grains of magnetite, with a little quartz between the grains; every intermediate stage between almost pure magnetite and pure quartzite can be found; the quartzites with least magnetite in them are met with near the base of the series. The Doornbergen, as a whole, contain so much magnetite that a magnetic compass is of very little use in their neigh-

bourhood. The jaspers are very fine grained rocks which break with a smooth conchoidal fracture. They are made up of extremely minute crystalline particles of quartz, and are coloured by oxides of iron of various degrees of hydration. The crystalline structure is due to changes that have taken place since the formation of the sediments. The jaspers often contain much magnetite in small grains and crystals. In the lower part of the series near Prieska Poort some highly ferruginous rocks with oolitic structure are interbedded with the more usual type of rock. The oolitic beds were probably ferruginous limestones that have been altered to their present condition. The magnetic quartzites and jaspers were probably highly ferruginous rocks when deposited; the thin layers of various compositions continue for considerable distances without appreciable variation, and are inexplicable on the assumption that the iron was brought into its present position by infiltration.

The Griqua Town beds are the home of the blue crocidolite (a fibrous amphibole related to riebeckite), which is used for various purposes under the name of asbestos;[1] the alteration product due to the oxidation and slight enrichment by quartz of the amphibole fibres is called griqualandite. There are many stages in the process; sometimes the crocidolite is partly replaced by quartz before any oxidation takes place, and a hard blue mineral results, in other cases the

[1] True asbestos is another variety of amphibole; another mineral, chrysotile, found in veins in serpentine, is often called asbestos, and is used for similar purposes.

oxidation, made obvious by the yellow-brown colour of the fibres, is in advance of the silicification. The ultimate product is a very hard mineral which takes a fine polish, and has a delicate fibrous structure preserved in it giving rise to the beautiful chatoyant lustre characteristic of the mineral. The unaltered crocidolite is found in blue-green, heavy, slaty rocks, which are much softer than the jaspers. Thin vein-like layers of crocidolite parallel to the bedding planes are found in the slates, usually in places where the slates are bent, and the layers are thickest in the crests and troughs of the folds, often disappearing altogether when followed along the limbs. The fibres stand perpendicular to the surfaces of the layers. The griqualandite occurs only in the jasper slates; these facts point to the simultaneous conversion of the heavy slates into jasper rocks, and of the crocidolite into griqualandite.

The surface of some of the beds in the series bear well-preserved ripple markings, which are crossed by a sharply defined set of ridges and troughs due to subsequent movements in the rocks.

The Griqua Town beds are often very much folded; in the Doornbergen they occupy the bottom of a trough-shaped fold running north-west, which is partly overturned, so that on the south-west flank of the range they dip south-west towards the granitic area between that range and the ridge of 'Keis hills on the western border of the division of Prieska. There are many isolated patches of highly magnetic quartzites and white quartzites, which rise above the general surface of the granite and gneiss. One such mass is twenty miles

long; it stretches from Zwart Kop Pan to Jackals Water. Whether it belongs to the Griqua Town or Campbell Rand group is uncertain, but it and the other similarly situated lenticular masses may be looked upon as pieces of the same rocks that form the Doornbergen, separated from the main area by denudation in an intensely folded district, that is further complicated by the intrusion of the granitic rocks, as well as other igneous materials which we shall speak of later.

The thickness of the Griqua Town series is not known, but it must be considerable, although the apparent thickness in Prieska is certainly much increased by folding. The top of the group has not yet been found.

THE MATSÁP SERIES.

The Matsáp series forms the Ezel Rand in Prieska, and the Langebergen and Matsáp hills to the north of the Orange River. It is composed of quartzites and coarse grits with conglomerates at the base. The conglomerates contain many pebbles of jasper and magnetic rocks probably derived from the Griqua Town beds. The grits usually have a peculiarly mottled colour. The quartzites and grits are distinguishable in even small pieces from both the Campbell Rand and 'Keis quartzites. In the Ezel Rand the beds dip towards the north-north-west at fairly high angles, and are at least 3,000 feet thick. In the Langebergen they are more folded than in the Ezel Rand, but parts of the rock in the latter range also show evidence of having been subjected to great pressure and movements; some of

...most lost the

FIG. 10.—Section through Ezel Rand. Distance 14 miles. Vertical scale $\frac{1}{4}$ in. to 1,000 feet.

1. 'Kels series.
2. Quartzites } Campbell Rand series.
3. Limestones }
4. Amygdaloidal lava.
5. Matsap series.

Much remains to be done before the sedimentary rocks of Prieska and West Griqualand can be properly understood.

There is a parallelism between the Campbell Rand, Griqua Town, and Matsáp series and the Transvaal rocks which Dr. Molengraaff considered to belong to the Cape system,[1] an opinion he has lately[2] seen reason to modify in view of the probably greater age of the Griqualand and Prieska beds. It has already been mentioned that the Campbell Rand and Griqua Town beds probably extend to the Transvaal border. From Dr. Molengraaff's description of the Black Reef, Dolomitic and Pretoria series, it seems very probable that they are the same beds as those called the Campbell Rand and Griqua Town beds by Stow. Dr. Molengraaff's account of the Waterberg sandstones in the Palala plateau agrees rather closely with those of the Matsáp beds in Prieska[3] and West Griqualand, except that the Waterberg sandstones are thought to succeed the Pretoria beds conformably, although usually separated from them by the great laccolitic intrusion of the Boschveld red granite and its local modifications, the "newer granite" of the Transvaal, an intrusion that has no exact analogue in Prieska.

The beds in the two countries may be tabulated thus:—

Cape Colony.		*Transvaal.*
Matsáp series - - - -		Waterberg sandstones.
Griqua Town series - - -		Pretoria beds.
Campbell Rand series	limestones,	Dolomite series.
	quartzites,	Black Reef series.

[1] Molengraaff (01). [2] Molengraaff (03).
[3] Molengraaff (01); *Geol. Comm.* (99), p. 82; Stow (73), p. 632.

It will be noticed that the 'Keis series finds no place in this comparison, but if that group really lies unconformably below the quartzites and limestones of the Campbell Rand, a not improbable view, the Transvaal representative of the group must be looked for in the "Primary formation" of Dr. Molengraaff. If, on the other hand, the schistose rocks lying unconformably below the Campbell Rand series in West Griqualand prove to be distinct from the 'Keis beds, the latter may have to be regarded as part of the Campbell Rand group, though there seems to be but slight evidence in favour of that view at present.

The intrusive igneous rocks of Prieska are of great interest and of varied character, but only a short account of them can be attempted here. By far the most important are the granite and gneiss of the district between the Doornbergen and the western hills of the division, and the similar rocks of the Kaaing Bult to the west of the latter hills. It has already been stated that the foliation planes of the gneiss are in general parallel to the strike of the sedimentary rocks in its neighbourhood. It is probable that the granite and gneiss, the extreme types of each of which are connected by many intermediate steps, were intruded amongst the 'Keis, Campbell Rand, and Griqua Town beds during the production of the greater part of the folds into which these rocks were thrown. The acid igneous rocks as a rule do not show sufficient evidence of having been violently folded after their consolidation to permit the idea being held that they were subjected to the same degree of pres-

sure that affected the sedimentary rocks. At the same time their component minerals frequently show optical anomalies due to pressure; it is not unlikely that the intrusion and solidification of the granite and gneiss occupied a long period, and that we see in the gneiss the earlier and consequently most altered products of the acid magma. Occasionally the gneissose rocks have structures that were produced by pressure and movements after their consolidation, such as areas of quartz and felspar mosaic surrounding the larger felspar and quartz grains, and the development of thin layers of very minute white mica flakes at the contact of some of the other constituent minerals. Whether any part of the granite is of much later date than the bulk of the intrusions is not yet settled. Some of the very fresh looking granites on the farm Schalk's Puts might certainly be considered younger than the gneiss, but there are so many intermediate varieties that the evidence of a considerable difference in age between the extreme types must be clearly made out before that opinion can be accepted.

The chief constituents of the acid intrusions are quartz; orthoclase, microcline, albite, and an intergrowth of orthoclase or microcline and a plagioclase felspar; black and white mica, the latter sometimes (*e.g.* Grenaat's Kop and Alicedale) in crystals up to ten inches in width, but too frequently bent by the movements which the rock has undergone since its solidification; hornblende is not often met with; apatite and iron ores are not abundant; garnets occur, especially in certain gneisses, and in the rocks with the same con-

stituents as the granite but with granulitic structure. Tourmaline seems to be absent from the Prieska granites.

Pegmatite or graphic granite, chiefly composed of an intergrowth of microcline and quartz, forms a large mass in the neighbourhood of Saft Sit Pan. Quartz-porphyries are rather restricted in their occurrence; they have been found only within the granite areas, and are not known to traverse the surrounding rocks in the manner of the quartz-porphyries near Paarl Berg.

The granulites of Prieska are abundant and vary greatly in composition. They are fine-grained rocks, usually showing distinct banding on large weathered surfaces, but the banding is often unobservable on a freshly broken surface. They are usually dark in colour, but the more acid or siliceous types are light coloured. In general appearance they look rather like even-grained quartzites. It is only under the microscope that the distinctive features of the granulites are seen. The most striking character is the uniformity in size of the grains of the various minerals composing the rocks; another important feature is the almost complete absence of crystalline faces in the minerals, which seem to have separated out in a different manner from that usual in igneous rocks; enclosures of one mineral by another are abundant, but the enclosed mineral is irregularly shaped, usually with a rounded outline. Garnet, which is an important constituent of most of the Prieska granulites, is the only mineral which sometimes shows crystal faces, and it very often

contains small grains of more than one of the other minerals composing the rock. All the minerals in the granulites are remarkably fresh and free from alteration products. The rocks may be broadly divided into three groups: (1) Granulites made up of the same minerals as the granite and gneiss, *viz.*, quartz, felspar (orthoclase and plagioclase), garnet, and biotite. This seems to be a less abundant rock than those belonging to the two other classes to be mentioned, but on account of its being rather closely related to much of the gneiss, into which it passes by the coming in of a pronounced foliation and the increase in size of some of the felspars, it is easy to overlook small outcrops in the gneiss areas. (2) Hornblende-granulites, composed of quartz, orthoclase, albite, hornblende, biotite, magnetite, garnet, and sphene. The hornblende is a pale bluish-green variety, different from the hornblende of most of the hornblende schists. Garnet is a less abundant mineral constituent than in the next group. (3) Pyroxene-epidote-granulites, composed of plagioclase, augite, epidote, garnet, magnetite, sphene, and frequently hornblende. The pyroxene is a pale green or bluish-green monoclinic variety, diopside, and is slightly pleochroic. The abundance of epidote, which often forms a large part of the rock, is very remarkable.

The granulites form elongated outcrops in the granite and gneiss, with the longer axes of the areas parallel to the foliation planes of the gneiss; they have not been found as intrusions in the sedimentary rocks. The nature of their contact with the gneiss has not been made out, as the line of junction of the two rocks is

almost invariably concealed under the red sandy soil that the granite and gneiss give rise to. The composition of the pyroxene-granulites must be very different from that of any of the gneissose or schistose rocks yet found in Prieska, and it is therefore impossible to consider them as local modifications of any of the latter, as the biotite-granulites may be with regard to the gneiss. The amount of lime and alumina in the pyroxene-granulites must be greater than is usual in igneous rocks containing the same varieties of plagioclase. The granulites give one the impression of being intrusive, but the question of their origin is quite unsettled.

The hornblende-granulites are connected by intermediate varieties with some of the hornblende-schists, which form dykes in both the granitic and sedimentary rocks of Prieska. Two main varieties of the hornblende-schist occur, one contains blue-green hornblende, felspars, and much garnet and quartz; and the other is made of actinolite, with a very little felspar and quartz. The hornblende-schist dykes in the sedimentary beds are probably highly altered igneous rocks; the blue-green hornblende is at places so abundant that the rock consists of little else.

The blue amphibole called glaucophane forms an important constituent of some of the schistose rocks; the other minerals in the glaucophane-schists are epidote, quartz, orthoclase and microperthite.

There are several varieties of much altered rocks that originally consisted of augite and felspar, but which are now usually a mass of minute fibres of

hornblende, and small grains of epidote, calcite, quartz and felspar, although the remnants of the original augite which formed ophitic plates can be seen in some specimens; the outlines of the former crystals of felspar can often be dimly seen under the microscope. Up to the present time those rocks have not been traced into the typical hornblende-schist, but from the close resemblance of specimens gathered in one and the same district to the different stages in the Scourie dyke described by Mr. Teall,[1] in which the alteration of an augite-plagioclase rock into hornblende-schist, very like several of the Prieska schists, was proved, it is to be expected that the whole series of changes will be found in one rock-mass in Prieska. These altered augite-plagioclase rocks (dolerites) are always distinguishable in the field from the similar rocks with or without olivine belonging to the dolerite intrusions of late Karroo age which occur in Prieska both in the Karroo formation and in the rocks older than the Dwyka conglomerate. The Pre-Karroo dolerites are dull-looking and greenish in colour owing to the alteration of their constituents, but the later ones are bluish-black, and when freshly broken the felspar cleavage faces, even within a tenth of an inch of the weathered surface, are bright and unaltered.

There are some dyke rocks at Zwart Kop Pan and Zeekoe Baard that are made up largely of olivine and augite with some basic plagioclase; the olivine is partly changed into serpentine. These rocks, which have

[1] *British Petrography*, p. 197, etc.

rather too much felspar in them to be called augite-picrite, but may be named olivine-gabbro, have no apparent connection with either the older or newer dolerites, and their age is unknown, but the fresh condition of their minerals points to their being later than the Pre-Karroo dolerites and schists.

Two large masses of serpentine have been found in Prieska, one at Zwart Kop on Blink Fontein, and the other at Zoet Vley. They are almost entirely composed of serpentine with the addition of a small quantity of opaque iron ore and calcite or magnesite. The serpentine does not contain unaltered grains of any mineral that it could have been derived from, and the arrangement of the fibres is not like that in serpentines derived from olivine, but frequently seems to be due to the development of fibres parallel to the prism cleavages of a pyroxene, as the fibres often form a square net-work. The serpentine contains veins of chrysotile, a white or pale-green fibrous variety of serpentine which can be used for some of the purposes to which asbestos is put. The serpentine forms dykes or sheets in magnetic quartzites and jaspers probably belonging to the Griqua Town series. The Blink Fontein magnetic rocks are an outlier in the middle of the granite, but those of Zoet Vley occur as an inlier in the Dwyka conglomerate south of the Doornbergen.

Volcanic Rocks.

In the general description of the Prieska and Hope Town districts, published by the Geological Commission

in 1900, mention is made of two groups of amygdaloidal rocks, one of which was called the Beer Vley series; the other, the Zeekoe Baard amygdaloid, on account of its complicated field relationships, was regarded as intrusive. Since that report was written the rocks have been partially examined under the microscope, and there is reason to modify some of the conclusions based on the field evidence alone.

The Beer Vley group consists of amygdaloidal lavas of an andesitic type, with pseudomorphs of chlorite after hornblende and pyroxene; and more acid lavas, rhyolites with crystals of quartz and felspar lying in a devitrified matrix which has perlitic cracks in it. The amygdales in the Beer Vley rocks are filled with chalcedony and chlorite, rarely with calcite. Some agglomerates, evidently composed of fragments of andesites and more acid lavas, have been found interbedded with the lavas. Beyond the fact that these volcanic rocks are older than the Dwyka conglomerate nothing is known as to their age, for they have only been found as inliers in the Dwyka area at Beer Vley, Bidouw Kuil, Jorsten's Berg, and Brak Pan. They are apparently much less altered than the Zeekoe Baard amygdaloids; but the latter, being of a more basic type than the Beer Vley group, contained more minerals that are easily changed.

The Zeekoe Baard amygdaloids are compact dark blue and green rocks with amygdales of calcite, chalcedony, and chlorite, or a mixture of two or more of these minerals. They occupy a large area in Prieska, and also in Griqualand West. In Prieska they surround the south-west end of Ezel Rand (see Fig. 10), and

form a wide area between the granite and gneiss on the west, and the sedimentary rocks of the Doornbergen on the north-east; they also occur as a long strip in the granite area west of Prieska's Poort.

These rocks vary considerably in mineralogical composition. They are usually very much altered, and in specimens from some of the outcrops hardly any of the original constituents can be recognised; chlorite, epidote, calcite, and quartz make up nearly the whole of the rock in many cases, and all these minerals are probably alteration products. In no case has the original dark constituent of the rock been observed, although either hornblende or augite was certainly an important constituent of parts of the rock. At Blink Fontein the rock is less altered than usual, and is there composed of crystals of plagioclase, some of which is andesine, set in a very fine-grained ground mass of probably quartz and felspar, some chlorite and opaque iron oxides are also present. This rock is evidently a less basic one than the amygdaloid at other localities, such as Zeekoe Baard, where it has been largely altered to epidote and calcite. At only one place, near the south-west end of Ezel Rand, has a breccia or agglomerate been seen which might belong to this volcanic group, but there is some doubt as to the true relationship of the breccia to the volcanic group and the Matsáp beds.

There is a similarity between the Zeekoe Baard amygdaloid and the amygdaloidal rocks in the Transvaal that are now known to be older than the Black Reef series. In the Prieska district, however, there is a difficulty in supposing that the amygdaloids are older than the

Campbell Rand quartzites; for although they lie at the base of that series in several places, yet they are in contact with both higher and lower beds at other localities, and it is more in accordance with the observed facts to regard the amygdaloids as having been poured out at the surface subsequently to the folding and denudation of the Campbell Rand and Griqua Town series, but previously to the deposition of the Matsáp group.

It is possible that the Prieska amygdaloids may be found to belong to the same group as the Boschveld volcanic rocks of the Transvaal.[1]

The reasons for classing the 'Keis, Campbell Rand, Griqua Town and Matsáp beds as Pre-Cape rocks must now be explained. We have seen that the Matsáp beds are represented by a mere remnant in the Prieska Division; that they were much folded before the deposition of the Dwyka conglomerate is proved by the fact that the Dwyka and overlying beds lie horizontally and undisturbed in the same district. The conglomerate lies in the ancient valleys of the Doornbergen, which have to a large extent been re-excavated, so that only outliers of the conglomerate are left as witnesses that the whole range was carved out of solid rock in Pre-Dwyka and Dwyka times. In neighbouring localities the conglomerate rests upon the Griqua Town, Campbell Rand and 'Keis beds, as well as upon the granites and gneiss, proving that the whole thickness of the sedimentary rocks was removed from certain areas before the conglomerate was formed. The conglo-

[1] Molengraaff (01), p. 62.

merate has not yet been found lying upon the Matsáp beds, but fragments of these occur in it, and there can be no doubt that the greater part of the rocks belonging to the Matsáp series formerly present in Prieska were removed by denudation before the deposition of the conglomerate. Taking the thickness of the Matsáp beds as 3,000 feet, and that of the Campbell Rand and Griqua Town series together as 5,000 feet, and omitting the 'Keis altogether as being possibly of the same age as the Campbell Rand group, we have a total of 8,000 feet of rock removed from certain parts of the district before the conglomerate was laid down in the same area. It must be remembered that this thickness is a low estimate, and that the whole of the volcanic group is omitted from the argument on account of the uncertainty as to its age.

In this district, therefore, before the Dwyka conglomerate was deposited, the Campbell Rand, Griqua Town and Matsáp beds were greatly folded and the greater part of them was removed altogether. All this must have occupied a very long time in a geological sense. In the south of the Colony, as was explained in the Introduction, and as will be described in more detail in later chapters, there was a continuous deposition of sediments (the Cape formation) about 10,000 feet thick, before the conglomerate was laid down conformably on them. It is obvious that at any rate the upper part of the 8,000 feet of sediments that were removed in the north in Pre-Dwyka times could not have been formed during the deposition of the beds immediately preceding the Dwyka series in the south;

for the folding and denudation of the northern rocks must have taken place during that period or earlier. It is, of course, difficult to base an argument as to the contemporaneity or otherwise of the beds in the two areas on a comparison of the rate of deposition in the one and that of denudation in the other; but it is clear that the folding and removal by denudation of the 8,000 feet of sediments in Prieska must have occupied a considerable part of the time during which the 10,000 feet of the Cape formation were formed in the south and west of the Colony. When it is remembered also that 8,000 feet is a small estimate, for the upper parts of both the Griqua Town and Matsáp series are unknown, it must be admitted that there is strong reason to regard the Matsáp beds as of pre-Cape age, and still more so the Griqua Town series and the underlying rocks.

Namaqualand Schists.

Under this name Mr. Dunn includes the schistose rocks that cover wide areas in the Namaqualand Division; amongst them are hornblende-schists, epidote-schists and others that are igneous rocks greatly altered from their original condition; but there are also sedimentary rocks, such as conglomerates, quartzites, limestones and mica schists. Very little is known of these beds.

Near the Orange River there are some quartzites that Mr. Dunn regarded as Witteberg beds;[1] they lie flat and unconformably upon the Namaqualand schists.

[1] Geological sketch-map of South Africa (87).

From the accounts[1] of German South-West Africa it seems very likely that those quartzites are the same as those of the Huib and Han-ami plateaux, which are overlain by limestones, and are perhaps the western representatives of the Campbell Rand group.

Granite, Gneiss, etc., of the North-West.

A great part of the north-west is occupied by acid, igneous rocks. From the west coast, north of the Bitter River, these rocks extend across Little Namaqualand and Bushmanland into Prieska, where they are probably continuous with the gneiss and granite previously described. The geology of this great tract of country is only known in its barest outlines. The igneous rocks are probably intrusive in the Namaqualand schists. Their southern boundary in Van Rhyn's Dorp and Calvinia is the line of fault along which the Ibiquas beds are thrown down against them. To the east the boundary is formed by the Dwyka conglomerate.

Amongst the southern Bushmanland granites and gneisses there are rocks of peculiar types; some well-foliated gneiss at the base of the Langeberg in Calvinia consists chiefly of quartz, plagioclase, enstatite, hornblende and biotite; it occurs in bands enclosed in gneiss of a more normal character. Garnetiferous granite and gneiss are abundant in that area. The general strike of the foliation planes is somewhat to the north of east.

The copper ores of Namaqualand are chiefly found in a rock rich in hypersthene; it is called a greenstone by

[1] Von Reichenbach (96), p. 117, etc.

Wyley [1] and a dioritic rock by Schenck,[2] and appears to form bands in the gneiss. The ores were regarded by Wyley as long ago as 1856 as constituents of the igneous rock concentrated in certain parts of its mass, a view that has again been stated by Schenck. The principal ore is the purple bornite, but the less valuable copper pyrites, chalcopyrite, is abundant in some of the mines, and many other copper-bearing minerals are present in smaller quantities.

[1] Wyley (56), p. 5; and (57), p. 30, etc.
[2] Schenck (01), pp. 64, 65.

CHAPTER IV.

THE CAPE SYSTEM.

THE rocks belonging to the Cape system have only been found in the southern and eastern parts of South Africa; from Van Rhyn's Dorp in the west, round the coastal districts to the Gualana River, and again northwards from the St. John's River into Natal the Cape system plays an important part in the structure of the country.

The true succession of these rocks was made out in part by A. G. Bain, but the numerous folds they have been thrown into in the west together with some lithological resemblances between parts of the two upper series were responsible for the mistake he made in limiting the occurrence of the Witteberg series (the "Carboniferous" group of Bain) to the eastern province. Moreover it is evident from the gap left in his map between the Kammanassie and Cockscomb Mountains that Bain never had the opportunity of connecting the west and east satisfactorily. This was partly accomplished by Wyley and Dunn; but meanwhile a serious error had been introduced by certain observers[1] taking the Bokkeveld beds to be lower in stratigraphical position than the Table Mountain sandstone, a mistake that

[1] Rubidge (58), p. 195, etc.; Hochstetter (66), p. 31, etc.; Cohen (87), p. 202, etc.

led to the identification of the Bokkeveld and Malmesbury beds on the one hand and of the Table Mountain and Witteberg series on the other. This unfortunate confusion which is not met with in the maps or writings of men who had a considerable personal knowledge of the rocks concerned, such as Bain, Wyley and Dunn, did much to obscure the structure of the Colony. The work of the survey has clearly demonstrated the correctness of Bain's view of the superposition of the Bokkeveld on the Table Mountain series, and the extension of the Witteberg series over wide areas in the south-west, which were indeed made plain by Wyley[1] and Dunn.[2] The three members of the Cape system have now been so frequently traversed and mapped between the Cederbergen and Uitenhage by the geologists of the Geological Commission[3] that there can no longer be any doubt as to their relationships to one another.

The Table Mountain Series.

This group of rocks forms the most conspicuous features in Cape Colony. Table Mountain itself, rising 3,553 feet above the sea, is visible long before the ship that brings the new-comer to South Africa reaches Table Bay, and on the mountain several characteristics of the series can be seen. The Peninsula mountains, however, are merely small outliers of the main portion of the Table Mountain beds in the Colony.

[1] Wyley (59). [2] Dunn, (72, 75, 87).
[3] *Geol. Comm.* (96-99). For a more detailed account of the history of the question see Corstorphine, *Geol. Comm.* (97), p. 31, etc.

A description of the distribution of the series will serve also as a description of the main tectonic or structural features of the southern part of the Colony. The broad outline of the structure has been given in the Introduction, but as nearly every important anticline in the south is marked on the surface by a ridge of Table Mountain sandstone a more detailed account will not be out of place here. The position of the main anticlines mentioned below will be found in Fig. 3, and in the map at the commencement of the volume.

On the seaward side of the folded belt of sedimentary rocks forming the second of the three regions into which the Colony is divided in the Introduction for the purpose of a general description, the Table Mountain sandstone becomes less steeply folded over large areas than anywhere within the belt itself. On the west, in the coastal plains of Clanwilliam and Piquetberg, the sandstone lies at low angles; by its removal the underlying Malmesbury beds and granite have been laid bare in the divisions of Van Rhyn's Dorp, Piquetberg, Malmesbury, Cape, Paarl and Stellenbosch, and the outliers of the Peninsula mountains, Riebeek's Kasteel and Simon's Berg bear testimony to its former extension over that part of the Pre-Cape region of the south-west as a gently undulating mass.

A long outlier, faulted down on the north-east side, forms Joosten Berg in the south of the Malmesbury division; Klapmuts Hill, on the same line of strike, is a similar faulted outlier north-west of Simon's Berg.

To the east of the Peninsula the present coast line passes somewhat irregularly through the marginal part

of the folded belt, for although the Table Mountain sandstone is more folded than in the Peninsula or Piquetberg, yet the plications are fewer and much less abrupt than farther inland. The shore at Cape Hangklip, Hermanus, Danger Point and Agulhas, as well as at many intermediate points, is cut out of the slightly bent sandstones. East of Agulhas the coast trends to the north of east and cuts across the folded belt slantingwise, and the sandstones of Capes St. Blaize, St. Francis and Recife are highly inclined, for they lie well within the folded belt. There is no direct evidence of the nature of the rocks under the sea floor, but it is probable that the Table Mountain sandstone is continued in a slightly bent condition some distance towards the edge of the Agulhas bank. The condition of the sandstone off the south-east coast, if it exist there, is of course quite unknown, but from the close analogy between the structure of Pondoland and Natal, and that of Van Rhyn's Dorp, we may suppose that the Table Mountain series formerly extended in a slightly bent condition right round the outer side of the folded belt.

In the west the first (see Fig. 11) pronounced folds met with form the sandstone mountains on the left side of the Olifant's River valley, where the sandstone is thrown into gentle anticlines trending north-north-west. The valley of the Olifant's River, from its source west of the village of Ceres to a point below Clanwilliam, occupies a syncline in which remnants of the Bokkeveld beds are still preserved at three places. South of the Pikenier's Kloof the western limb of the anticline west of the river has mostly been removed by denudation, and

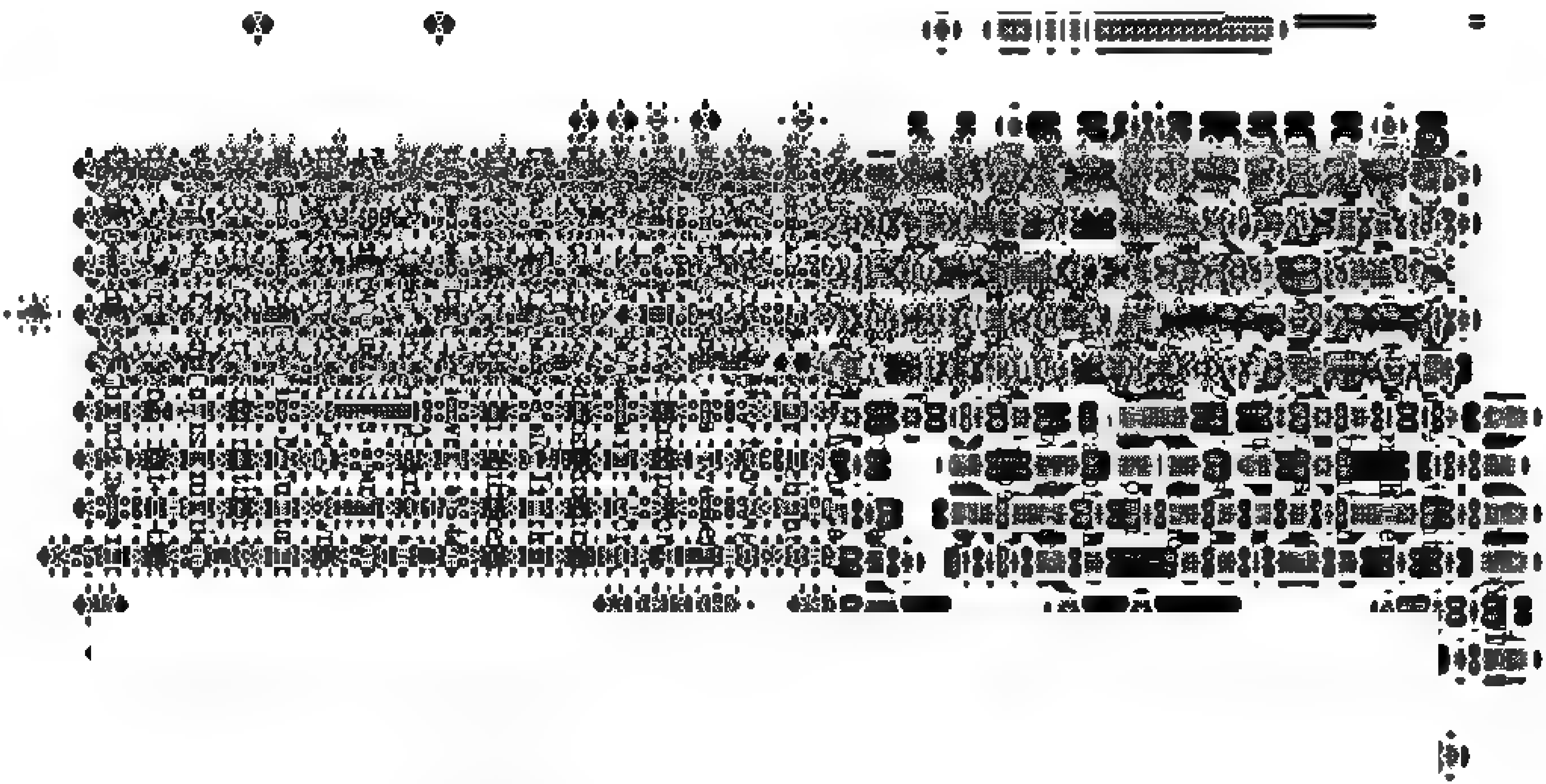


FIG. 11.—Section from Piquetberg to the Karroo. Distance about 68 miles. Vertical scale $\frac{1}{8}$ in. to 1,000 feet.

1. Malmesbury beds (the folding is diagrammatic).
2. Table Mountain series.
3. Bokkeveld series.
4. Witteberg series.
5. Dwyka series.
6. Ecca series.
7. Dolerite dyke near Hartnek's Kloof.

Plate II.—Matsiekamma from the N.W., a projecting portion of the Bokkeveld Mountain escarpment. The flat summit, with a kranz 600 feet high, and a further 400 feet of the slopes are made of Table Mountain sandstone; the lower slopes are of Malmesbury beds.

the other into the Oorlog's Kloof River that lies in a deep precipitous valley about six miles behind the escarpment. The Table Mountain series comes to an end with the Bokkeveld Mountain, although the escarpment is continued some miles farther in the same line by the Ibiquas beds. The sandstone is only some three feet thick at its termination, but gradually increases in thickness southwards, so that at about thirty miles south of its northern limit possibly the whole 5,000 feet, the average thickness of the Table Mountain series, may be present. East of the Olifant's River lies the great anticline of the Cederbergen, which trends nearly north-west in its northern portion, but turns nearly north and south at the Trigonometrical Station (6,336 feet above the sea) ; in the same neighbourhood the syncline of the Cold Bokkeveld separates the main anticline from that of the Schurfteberg[1] of which the axis diverges in a south-south-east direction and is inclined southwards, so that the anticline disappears near the Houd den Bek's River. The main Cederberg anticline is continued in the Cold Bokkeveld Mountains and the southern Schurftebergen. From the Schurftebergen the anticline passes round the warm Bokkeveld into the Hex River Range, closely backed by the Olifant's River syncline, so that the Table Mountain series in the block of mountains traversed by Mitchell's Pass is bent into an S-shaped fold (see Fig. 12). This fold becomes wider in the Hex River Mountains, the

[1] There are two ranges called Schurftebergen (Rough Mountains) in that part of the Colony. The one here referred to is the more northern range ; the other flanks the Warm Bokkeveld on the west and is the direct continuation of the Cederberg anticline.

[illegible] t of that range, [illegible] cline is occupied [illegible] kkeveld beds of [illegible] ver Valley. This [illegible] structure is re- [illegible] he Keerom and [illegible] Bergen, the anti- [illegible] north forming [illegible] boom Berg and [illegible] the Bokkeveld [illegible] Coo and the [illegible] e southern limb [illegible] cline, rather a [illegible] d belt than a [illegible], forms the com- [illegible] of the Lange- [illegible] which we shall [illegible] ently.

[illegible] the Winterhoek [illegible] mass, which is [illegible] rn limit of the [illegible] nticlines of the [illegible] River area, the [illegible] the Klein Berg [illegible] Rivers have been [illegible] rough the Table [illegible] series, and are [illegible] by the Pre-Cape [illegible] rating the two [illegible] tainous ridges of [illegible] Zand - Drakens-

tein, and the Witzenberg-Mostert's Hoek Ranges. The former or western one is a simple ridge in its northern part, lying on the Malmesbury beds which are exposed on either side, but south of Slang Hoek its character changes; it widens out considerably, the strike of the sandstones changes and turns eastward and the dip becomes northerly; the Bokkeveld beds are first met with near Dasbosch River, where the strike of the Table Mountain series again turns through an angle greater than a right angle, and runs south-west to the Bier River Mountains near Villiers Dorp, where a narrow south-west syncline, in which the Bokkeveld beds still remain, separates the mass from the easterly trending range of the Donkerhoek, Boschveld, and Zonder Einde Mountains.

The great block of mountainous country between Rawsonville and Cape Hangklip contains two irregularly shaped depressed areas, in which lie the Bokkeveld beds of the upper part of the Zonder Einde River, and those of the Houwhoek and Palmiet River district. The Groenland and Houwhoek Mountains have a north-west trend, and separate the two depressions. The country between Rawsonville and Cape Hangklip was, as it were, the hottest part of the battle-field where the north-south and east-west fold-producing forces met, and the resulting ridges and depressions trend north-west or north-east. The Boschveld, Groenland, and Houwhoek Mountains are the chief ridges of the north-west group, and the Zonder Einde and Houwhoek-Palmiet River Bokkeveld areas the corresponding depressions. The north-east group of ridges are the

Dwars Berg-Bier River, and the Donkerhoek-Paarde Berg ranges, while the corresponding synclines are those of the Villiersdorp and Bot River Valleys. The north-east folds extend eastwards as far as Lady Grey (Robertson) and as far north as the extremity of the Hex River Range.

The Zonder Einde Range, complicated by the north-east folds of the Lady Grey area, is an irregular anticline, and the beds in the northern limb dip down and come up against the Malmesbury beds along the great Worcester fault; to the south of the range the Zwartberg, better known as the Caledon Mountain, is the only conspicuous anticline that lies in the wide, synclinal area between it and the less disturbed Table Mountain sandstone ranges that stretch from Babylon's Tower to Bredasdorp.

The Worcester fault, with a maximum throw of more than 10,000 feet extends at least seventy miles towards the east, and plays the part of the southern limb of the complex anticline of the Langebergen. The Langebergen anticlines, although the mountains are known by other names, such as the Attaquas, Outiniquas, Long Kloof, Zitzikamma, and Kareedouws Mountains in their eastern portions, reach the sea over 300 miles from their commencement at Hex River. At many parts of the Langebergen the beds are overturned, so that the sandstones are overlain by older rocks on the south side, and underlain by newer beds on the north flank. The structure of the range is shown in the sections Figs. 1 and 13.

To the north of the western part of the Langebergen the Table Mountain series disappears under the Bokke-

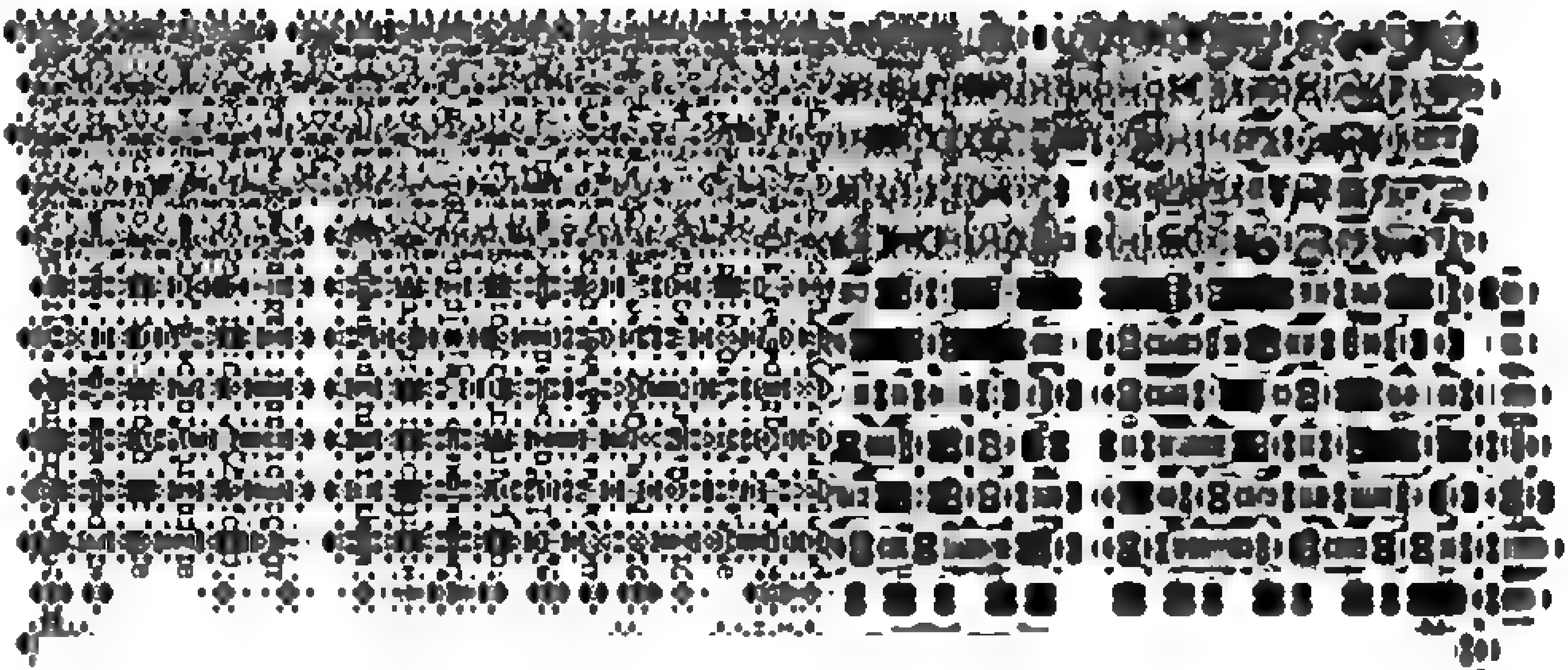


FIG. 13.—Section through the Langebergen in the neighbourhood of Oudebosch beacon showing the nature of the folding. Distance 11 miles. Horizontal and vertical scales the same.

1. Table Mountain series. 2. Bokkeveld series. 3. Uitenhage series. 4. Surface quartzites and gravels.

pear in Anysberg, and are continued in the Zwartberg range 160 miles before the axis of the fold gradually sinks below the Bokkeveld beds near the Zuurberg Poort. About twenty miles west of Ladismith village, the Amalienstein fault is first met with, throwing down the Bokkeveld beds on the south against the Table Mountain series; the throw increases eastwards, so that near Amalienstein the Bokkeveld beds are in contact with the Cango series. This fault is in many respects like the Worcester fault, and replaces the southern limb of the Zwartberg anticline for a considerable distance—over sixty miles.

The Zwartberg anticline has at least as complex a structure as that of the Langebergen, and is also overfolded in many places (see Plate III.), especially between Prince Albert and Klaarstroom; the overfolding affects both the north and south flanks. On the north the later rocks, from the Bokkeveld to the Dwyka, dip south towards the mountains near Prince Albert (see Fig. 6), and, as was described in the account of the Cango series, the Table Mountain sandstone dips in places below the latter. Where the Gamka River traverses the mountains there is a synclinal fold bringing in the Bokkeveld beds in the middle of the range, thus dividing it into two distinct anticlinal ridges for some ten miles. The highest point on the range is the peak near Seven Weeks' Poort, 7,627 feet; the curious tower-shaped peak called Tover Kop is some 400 feet lower. Near Klaarstroom the Zwartebergen decrease considerably in width on account of the northern portion of the range separating from the southern and plunging below the Bokkeveld beds,

[illegible] ates of the Table
[illegible] i Meiring's Poort

Between the Zwartebergen and the Outiniquas lies the great ridge called the Kammanassie Mountain, a bow-shaped anticline of sandstone with the concavity towards the north; the east and west ends of the axis pitch in those directions. Between the Kammanassie and the Outiniquas there is a much-folded ridge of sandstone that diverges from the main range near the Montagu Pass, and extends eastwards to form the Kouga Mountains.

The Table Mountain and Bokkeveld series, of which the country between Willowmore and Knysna chiefly consists, have been intensely folded in this region, and the mountain ridges are formed by very sharp isoclines of sandstone.

East of the Willowmore and Uniondale divisions little is yet known of the distribution of the various formations, but it is probable that the Baviaan's Kloof and Kouga Ranges are continued under other names to near the mouth of the Gamtoos River. Farther east and north-east of the Gamtoos River there are several large anticlinal ridges of Table Mountain sandstone, but their exact limits and characters are not known; the Eland's Berg and Great Winterhoek Mountains are the chief ones. It is probable that the Cape Recife sandstones are the most easterly part of the Table Mountain series on the coast in the folded belt, and the next appearance of this group near the coast is at St. John's, where it forms the great massive walls on either side of the river, called the Gates of St. John's. This block of rock, cut into two by the river, is separated by faults from the surrounding beds, which belong to the Dwyka

and Ecca series. The St. John's sandstone lies horizontally. A few miles north-east of St. John's the Table Mountain sandstone is again met with lying horizontally, overlain to the north-west by the Dwyka conglomerate, and on the south-east bounded by the ocean or separated by a fault from a narrow strip of younger rocks (Ecca and Cretaceous) between it and the sea. The difference in level between the sandstone on the coast and that forming the plateau behind the coast is due to the cutting back of the lower terrace by the sea at no very remote period, and certainly not to folds or faults bringing the sandstone down near the coast.

The Table Mountain series is remarkably constant in lithological characters throughout its extent. The maximum thickness is about 5,000 feet, and of this more than 4,000 feet are sandstones or quartzites. The difference between a sandstone and a quartzite is that the component grains are more loosely held together in the former than in the latter, in which the cementing material is quartz. When a sandstone is broken, the fresh face is rough and dull, owing to the fracture passing round or between the grains of sand which form the rock; a quartzite, on the other hand, has a smoother and brighter face because the fracture passes through the component grains, which are closely joined together by the siliceous cement. It is sometimes found that a large block of sandstone long exposed to the weather becomes a quartzite near the outer surface, owing to the deposition of silica between the grains. On the other hand, some quartzites become loose and

crumbly outside on account of the removal of the cement.

The whitish-grey colour of so much of the sandstone belonging to this series is due to weathering. At a distance of one or two feet from the outside the rock is usually blue, owing to a small quantity of iron in the state of ferrous compounds. The reddish-brown layer so often seen on the broken surface of a large block of sandstone is produced by the oxidation of the ferrous compounds and the formation of a brown hydrated sesquioxide. This is slowly removed from the outer surface, so that a narrow band of light grey or white rock lies between the brown band and the exterior. The red stains so often seen on the sandstones are deposits of this red oxide of iron.

The sandstone has generally a very rough surface, frequently hollowed out so that it is covered with small and large projections, between which are shallow depressions that hold water for some time after rain. Particles of sand collect in these and give the depression a smoother surface than it otherwise would have had, by being moved about in it by strong winds. The gradual lateral growth of the hollows on steeply inclined surfaces of sandstone may eventually give rise to a perforation, or small arch, by meeting a joint plane or a second depression formed on another surface of the rock.

The sandstone is very much jointed; and as the processes of weathering naturally go on more easily along joint planes than elsewhere, for the loosened grains are soon removed by the rain or wind, the

large exposed surfaces of sandstone are usually divided up by two or more sets of deep cracks, to which another group is added if the beds are so steeply inclined that the bedding planes make a high angle with the ground. Where these cracks become deeply eroded and are set at close intervals the ground is extraordinarily rough and difficult to traverse. The moderate effects of weathering along joints are familiar to every one who has been to the top of Table Mountain, where there are many curiously shaped knobs and pinnacles due to this cause combined with the unequal weathering of the surface. On the eastern slope of the Cederbergen, below Sneeuw Kop, on which a beacon of the geodetic survey stands, the surface of the hill is extremely cut up by these eroded joints. There are two main sets of joints on that slope, roughly parallel and at right angles to the strike of the beds, and a third group is sometimes developed. Weathering and erosion have gone on to such an extent that the mountain side is covered with an intricate mass of vertical walls and pinnacles of rock from five to forty feet high. Although such a fine development of joint weathering is not often met with, similar features are common on all the folded mountains made of the Table Mountain beds.

A very frequent characteristic of the sandstones of this group is the occurrence of round pebbles of white quartz up to three inches in diameter. They usually occur singly, more rarely in thin layers a few feet long and about an inch thick. The pebbles themselves are rarely more than an inch in diameter. It is rather difficult

to explain the frequence of isolated pebbles in the sandstone without recourse to some agency that lifted pebbles from the shore and dropped them in deeper waters. There are several means by which this may be done; in warm latitudes, seaweed torn from the shore and drifted out to sea must often carry out pebbles and bits of rock; but in cold climates floating ice is a more powerful and usual agency, and may have been the cause of the presence of the pebbles in the Table Mountain sandstone.[1]

Conglomerates are remarkably scarce in this group, especially when it is remembered that the sandstones are frequently coarse-grained rocks. Hitherto thick conglomerates have only been noticed in the west of the area occupied by the group, at Pikenier's Kloof (Grey's Pass), Baboon Point, and a few other localities in that district; one of the most conspicuous constituents of the Baboon Point conglomerate is red jasper, a rock that may have come from the Griqua Town series. The majority of the pebbles are quartzitic rocks of different varieties. Granites and quartz-porphyries have been found in the small outliers of Klapmuts Hill and Joostenberg, as well as at Baboon Point, but they are not abundant. Fragments of slate, strange as it may seem, considering the nature of the underlying rocks, are rare in the sandstones and conglomerates.

In the Peninsula and Stellenbosch areas the base of

[1] This was suggested to me by Mr. Dunn in a letter written after reading an account of the glacial conglomerate in this series on the Pakhuis Pass. He had not previously put forward this explanation on account of the lack of other evidence of glacial action in those times.

the Table Mountain series is usually a red micaceous gritty shale. On the north face of Table Mountain this is the first rock met with at the junction with the granite or Malmesbury beds. In many parts of the Langebergen there is a thick band of shaly beds near the base of the series, but the lowest beds are usually quartzites (see Plate I.). On the Montagu Pass the shales near the bottom of the series are exposed in the road cutting, and are found to be a crumpled silky phyllite or schist, in which the silky appearance is due to the development of minute flakes of a micaceous mineral.

In the western mountains a second shale band is found about 1,000 feet below the top of the series. The shales are usually hidden by debris from the sandstone cliffs above them, and it is only on road cuttings and tracks across its outcrop that the rocks forming the shale band can be well seen. The shales are exposed on the Mitchell's Pass Road, where they are deeply weathered into a red micaceous clay. On the Pakhuis Pass the shale band is exposed along a distance of three and a half miles at the top and on either side; the rock is here a greenish-brown mudstone, a typical shale in places but generally too thickly bedded to be called a shale. The most interesting point about the Pakhuis section is the occurrence of pebbles up to five inches in diameter scattered irregularly through the shale and mudstone, without any tendency to form beds of conglomerate. Several of the pebbles have been found to be flattened on one or more sides and deeply striated in the manner characteristic of pebbles that

have come from a glaciated region. The flattening and striation are produced by the rubbing of the pebble, held by the ice at the bottom of the glacier, upon the floor, rocky or fragmental, over which the glacier moves. The floor and the fragments lying upon it become striated also, and may furnish striated pebbles to beds being deposited off the glaciated land. There is no other agency known by which the typical striated pebbles and boulders are given their peculiar features. The erosion caused by wind-borne sand produces quite different effects, which can be seen in several districts of the Colony. The frequent sliding of debris from a hillside over a smooth rock face may smooth and scratch the rock, but does not make flattened and striated pebbles. The slickensides on rock on either side of a fault plane may sometimes be mistaken for a glaciated floor, and the evidence for regarding any given striated surface as due to glaciation must be clear and free from suspicion in this respect; but rock movements cannot give rise to the flattened and well-scratched pebbles that are embedded in a fine-grained mudstone at moderate distances from one another. There are several conglomerates in Cape Colony that have suffered great deformation by earth movements, such as those of the Matsáp and Cango series, but their contained pebbles and boulders, although often pulled out of shape and fractured, have never been found to have the characteristics of glaciated pebbles. In the conglomerates at the base of the Uitenhage series, which have at places been considerably disturbed, there are found fractured and indented pebbles, due

to the crushing, or gradual deformation, of one upon another,[1] but much searching has failed to discover one that could be mistaken for a glaciated fragment.

The occurrence of flattened and striated pebbles scattered at intervals through a fine-grained laminated rock is very strong evidence that glacial conditions prevailed on the land whence the pebbles came, and that these pebbles were carried away from the land by floating ice and dropped by the melting of the ice on to the mud being deposited at the bottom of the water.

The junction of the shale band on Pakhuis with the underlying sandstones is not seen, but there is no reason to suppose that there is an unconformity at its base.[2]

The materials of which the pebbles are made include granite, amygdaloidal lavas, quartzites, grits, jasper and vein-quartz. The vein-quartz pebbles are often smooth and almost spherical in shape, like the isolated quartz pebbles in the sandstones and quartzites both above and below the shale band.

The sandstones and quartzites are usually false bedded, and in any natural section of a considerable height examples of false bedding can be found.

No traces of fossils have yet been found in the Table Mountain series, although some of the shales appear to be favourable rocks for the preservation of organic remains. It must be remembered, too, that these rocks,

[1] Schwarz (03), p. 398 and Pl. V., Fig. 1.

[2] Fuller descriptions of this interesting evidence of glacial action in the Table Mountain series have been published in *Ann. Rep. Geol. Comm.* (00), p. 79, and Rogers (03).

as well as several other formations in the Colony, have not been properly searched for fossils. Any one who thinks of the amount of work done in the north of Devonshire, for example, by two generations of geologists before the Morte slates were found to be fossiliferous, will not be surprised at the apparent absence of organic remains from some of the colonial beds.

The question of the conditions under which the Table Mountain series was deposited has not yet been satisfactorily solved. The rocks are, with the exception of the shale bands, essentially coarse-grained deposits, yet this character is maintained over very wide areas; from the Peninsula to Algoa Bay, nearly 430 miles in a straight line, and from Cape Point to the north end of the Bokkeveld Mountain, a distance of over 225 miles, the same coarse sandstone with isolated quartz pebbles is met with; in Pondoland again, 290 miles from Algoa Bay, the sandstone is of identical character with that of the western area, and maintains its character, at least, as far as the Natal border. North of Agulhas the Table Mountain sandstone is seen at intervals for about 100 miles. It is clear, then, that the coarse sandstones that make up the bulk of the series were deposited over an area of at least 43,000 square miles, probably over more than 90,000 square miles, and even then the Pondoland outcrops have been left out of account owing to the uncertainty of the nature of the rock between these and Algoa Bay.

During the denudation of the land that furnished this great bulk of sand, mostly quartz sand, an equal or greater amount of finer-grained material, muddy matter,

must have been produced, but of these fine-grained sediments the only traces in Cape Colony are the shale bands interbedded with the sandstones. The shales belong to definite horizons, or, in other words, were deposited during a certain part of the period instead of the coarse sand which lies above and below them, but within the area of observation the coarse deposits do not pass laterally into the fine-grained ones. In any wide area of deposition such as that with which we are dealing, it is usual to find a considerable change in the nature of the material deposited, except in the case of oceanic deposits, the organic oozes and red clays which are formed far from land and under circumstances that vary but slightly over immense regions. The sandstones with which we are dealing, however, must have been formed near land, possibly to some extent on the land.

The absence of fossils throughout the series is a significant fact, although much weight must not be laid upon it until the shales have been better searched than they have been up to the present time.

In some desert regions great thicknesses of sandy material are accumulated over large areas by the wind and occasional heavy rains carrying down the debris of the surrounding mountains and hills into plains that have become waterless through change of climate. The rivers that once drained the plains and took away the sand and mud from the hills, cease to run, and the occasional heavy downpours are not sufficient to supply the rivers regularly, but tend to choke up the former channels and to distribute the gravel, sand and mud more evenly over the low ground on which temporary

lakes are formed during heavy rain. In desert deposits many of the phenomena produced by ordinary deposition under water are noticed, such as false bedding and the alternation of fine and coarse beds, but there are also certain features that are not usually found in ordinary deposits, such as intercalations of layers of soluble salts deposited on the evaporation of the water containing them, the very rounded, almost spherical, form of many of the sand grains, the scarcity of fossils and the absence of marine forms amongst those that do occur, and the presence of sand-etched stones.[1]

It cannot be said that the Table Mountain series contains much evidence of having been formed under desert conditions, although the fact of there being such a great thickness of unfossiliferous sandstone points in that direction.

If the Table Mountain sandstone is regarded as an ordinary coarse deposit formed in either a fresh water basin or the sea, the land from which the material was washed cannot have lain far from the present outcrops of the rock. The only evidence of the closer proximity to land of one part of the sandstone than another is the greater development of conglomerates on the west, in the Piquetberg Division and the Olifant's River Mountains, than elsewhere. There is no such evidence known from the Bokkeveld Mountain, or along the Zwartebergen, or the south coast. At present, then, we must

[1] The subject of desert conditions in relation to the formation of deposits is one that has by no means been exhausted by geologists. It is only in recent years that much attention has been paid to it. The best source of information is Professor Walther's book *Das Gesetz der Wüstenbildungen*, Berlin, 1900, which is also very well illustrated.

conclude that while the nature of the rock renders it probable that the Table Mountain series, so far as exposed in the Colony, was formed not far from land, and that consequently the land lay more or less parallel to the present distribution of the series, the only definite clue to the position of any part of that land is to be found in the conglomerates of the west.

The Table Mountain series furnishes good rough building stone in many places, such as the Cape Peninsula, Hottentot's Holland, and Green River (Nieuwoudtville), where it has not been greatly disturbed by earth-movements. Owing to the quantity of unsuitable stone that has to be removed in quarrying the best beds of rock, it is not used so much as one might expect from the wide distribution of the sandstone. The stone is not easily worked, and is mostly used for foundations. In Cape Town the Huguenot Memorial is partly made of Table Mountain sandstone; and the new Harbour Board offices are built of the sandstone from a quarry at Grabouw beyond Sir Lowry's Pass. The sandstone from the latter place is more regularly laminated than is usually the case, and good-sized blocks can be obtained without much difficulty.

Irregular pockets and fissures in the sandstone are sometimes filled with pyrolusite, an ore of manganese, but the mineral has not been successfully worked yet. The fissures are usually along fault planes. Some old workings can be seen at the head of Du Toit's Kloof near the Paarl.

Gold has been found in small quantities at many places in the Table Mountain series, but except at Mill-

wood (Knysna), it has never attracted much attention. The gold hitherto obtained at Millwood is alluvial, probably derived originally from veins in the Outiniquas Mountains and the country south of them. There is still some doubt as to whether the bed rock at Millwood belongs to the Table Mountain series or to an older group. If the latter proves to be the case, the Millwood beds may belong to the same group that the galena and blende occur in at Maitland Mines, Port Elizabeth.

The Table Mountain series yields a poor, sandy soil, which in spots continually kept damp is black, owing to the presence of organic matter. Vegetation is abundant where the rainfall is heavy; a heavier rainfall is recorded on or near the mountains of the south and west than on the low ground on the coast side or on the inland flank. The most characteristic plants seen on this formation belong to the orders *Proteaceæ*, *Ericaceæ* and *Restionaceæ*, respectively the sugar-bush tribe, heaths and flowering rushes. The change in the character of the vegetation on passing from the Table Mountain series to another formation is usually very sharply defined. From the Bokkeveld Mountains right round the great sandstone mountains of the folded belt, the same, or similar shrubs and flowers are found. A most striking contrast to any one who is even slightly acquainted with the vegetation of the western mountains is seen on passing from the Karroo formation in Pondoland to the strip of country near the coast formed by the Table Mountain sandstone; leaving the monotonous grass veld of the interior of Pondoland one meets with the same flowers and small shrubs that are abundantly

found on the western mountains. It is difficult to understand how such a distant outlier can be clothed with the same vegetation as the main area by a process of colonisation and selection by the soil; probably the plants of the Pondoland coastal plateau arrived there when the sandstone was still connected with the western ranges by the more or less rectangular strip, corresponding to the bent ranges round the Warm Bokkeveld, that may still exist off the south-east coast between the Gualana and St. John's Rivers.

Owing to difficulty of access by road and the general poverty of the soil, there are few farms under cultivation on the sandstone areas. The mountain veld is mostly used for grazing. Very rarely one finds a farm, such as Mouton's Valley on Piquetberg, where many kinds of fruit are grown, wine and tobacco made, and fine plantations of oaks laid out on ground that was no better originally than that on hundreds of other mountain farms which are merely grazing veld.

From the old accounts of the Colony it is clear that the mountains of the south were once fairly well covered with forest, now represented by a few isolated patches, as at Groot Vader's Bosch near Swellendam. In the neighbourhood of the Peninsula and Stellenbosch, the oldest settlements in the Colony, the too free cutting down of the timber has been the cause of the almost complete disappearance of the indigenous forest, but farther north and east the chief cause of destruction has been the veld fires lighted for the purpose of allowing young grass and bush to spring up afresh for cattle to graze upon. There can be no doubt that the

hindrance of the forest growth is a great evil, except perhaps to the farmers whose cattle graze on some of the mountains. There is a well-supported belief that forest-clad hills receive a heavier rainfall than the same hills deprived of their trees; but the destruction of forest and bush has a much wider effect than this. Living vegetation and the accumulation of dead twigs and leaves hinder the rapid dispersal of rain water and bind the sandy soil, thus causing a more gradual delivery of the water into the streams, and at the same time allowing a greater proportion of it to sink into the ground than is the case in a deforested region. The rivers fed by the mountain streams, therefore, rise less suddenly and maintain their supply of water for a longer period; and the springs which get their water from the mountains are stronger and more constant.

The Cape Government is doing something in the direction of reforesting some of their mountains, but these efforts could be multiplied many times with very great advantage to future generations, even without taking into account the value of the timber, a considerable asset in a few years after a plantation is made. The only real difficulty in the way of maintaining extensive plantations is the reckless burning of the mountain veld, but in that matter a strong current of opinion seems to be setting in the right direction amongst farmers, especially in the Eastern Province, and if that opinion grows and becomes general throughout the districts concerned, there will be very little danger from fire.

The Knysna forest is chiefly on Table Mountain

sandstone, and far to the north-east the St. John's and Egossa forests are on the same formation. Elsewhere the forests are mere remnants preserved in steep kloofs, and they do not spread over large parts of the mountain sides.

The Bokkeveld Series.

The Bokkeveld series is everywhere found lying directly upon the Table Mountain series, with similar strike and dip, and there are no signs of unconformity between the two. In some localities, such as the small sandstone anticlines in the Warm Bokkeveld and the anticlinal ridge of Jan Niemand's Bosch near Houwhoek, water seems to have percolated freely at the junction of the two formations, the position of which is marked by a layer of crystalline quartz. There are few places where a clean-cut section of the junction can be seen, for the soft beds of the bottom of the Bokkeveld group have generally been worn away by small streams, the beds of which are choked up by debris from the sandstones when the strata are at all steeply inclined. Where the beds lie nearly flat, as they do north of the Doorn River in the Western Karroo, the junction is hidden under the soil. The best section hitherto found is that on the left bank of the Gamka River immediately above its great Poort through the Zwartebergen, and there "the end of the white sandstones and the beginning of the blue-black shales of the Bokkeveld is so sudden and exact that one can place a knife between them and say confidently that on one side are the rocks of the Table Mountain series and on the other those of

the Bokkeveld".[1] Other clean-cut sections through the junction may be seen lower down the Gamka (Gouritz) River in the Pogha Hills and near the new road to Cloete's Pass and at the north end of Meiring's Poort,

The Bokkeveld beds are well exposed in the Cold and Warm Bokkevelds, in the Hex River Valley especially between De Doorns and Klein Straat stations, and along the northern flank of the Zwartebergen. They occupy wide areas in the Ladismith Karroo and south of the Langebergen; but south of the Zwartebergen they have been greatly changed by the movements which gave rise to those mountains, and are much cleaved. They have only been found within the folded belt south and west of the Karroo. No outliers have been met with in the Pre-Cape region of the west and north, and in Pondoland they have been removed by denudation, if they were ever deposited there. There can be little doubt that they once overlay the sandstone of Table Mountain, although the nearest outcrop is at Grabouw, east of Hottentot's Holland, about thirty-six miles in a straight line from Table Mountain.

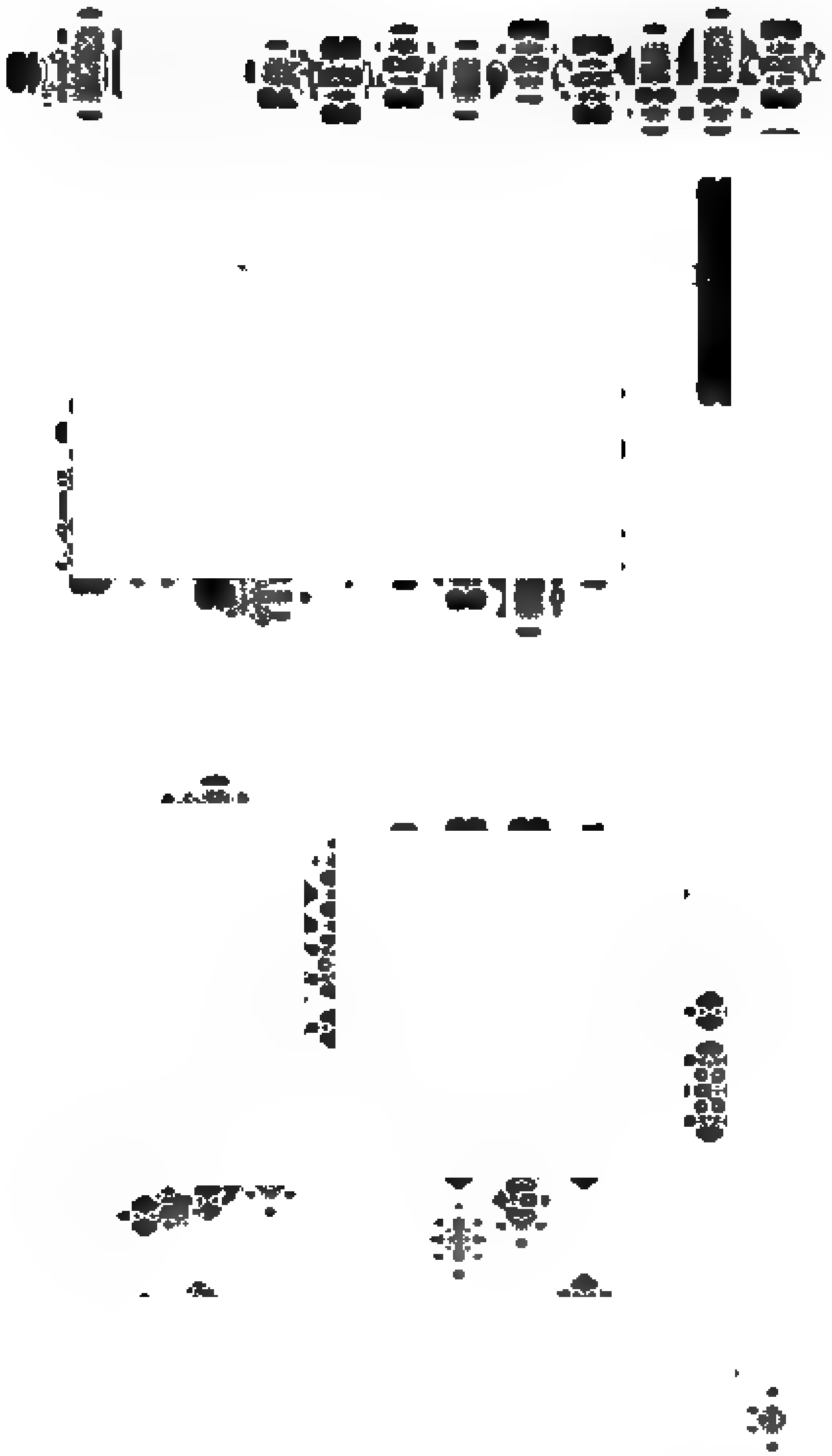
Where typically developed the Bokkeveld beds consist of shales and sandstone arranged in a definite order, although the details vary from one locality to another. The lowest division consists of shales and thin sandstones about 300 feet thick and contains many fossils, amongst which trilobites belonging to the genera *Phacops* and *Homalonotus*; brachiopods of the genera *Leptocœlia*, *Spirifer*, *Chonetes* and *Orthothetes*; *Orthoceras*, *Bellerophon*,

[1] Schwarz, *Geol. Comm.* (98), p. 36. A detailed measured action through the Bokkeveld beds will be found in that Report.

Nuculites and crinoids. The shales often contain spherical or elliptical nodules, which are partly filled with red or yellow ochre, sometimes used for making paints with the addition of oil. Another variety of nodule found in the shales is dark coloured inside, and often contains rather well-preserved fossils.

Some beds of the lowest shale group are coloured black by the amount of carbonaceous matter in them, and in places where the rocks have been intensely crushed these beds are represented by graphitic slate or schist, as on the north of the Pot Berg anticline near Port Beaufort and near Bredasdorp.

This subdivision usually forms a slope below a cliff or very steep rocky ground formed by the second division, the first or fossiliferous sandstone. The fossiliferous sandstone is a dark-blue rock weathering deep red outside; at some places the sandstone contains many fossils, especially *Spirifer* and *Leptocœlia*, but at other localities the sandstone is not nearly so fossiliferous. The beds of red-weathering sandstone are separated by blue shales very like those below and above this subdivision. The thickness of the fossiliferous sandstone reaches 150 feet. This rock can be seen north of the village of Ceres especially on the road up the Gydo Pass, where many fossils have been obtained from it. It is very often seen as an escarpment, the steep face of which is directed towards the Table Mountain sandstone. Such an escarpment occurs for a long distance, over fifty miles, on the east side of the Cederbergen, where, owing to the steep but constant dip of the beds south of Wupperthal, the



6

[illegible] beds.

[illegible] al size.

[illegible]

[illegible] size.

[illegible] size.

12

size.

from Reed.

whole of the Bokkeveld series is exposed within a short distance. In the view shown in Plate IV., taken on the west side of the Schurfteberg (north) anticline (Cold Bokkeveld), looking south, the escarpment of the fossiliferous sandstone is seen on the right of the road as a low ridge, and also on the horizon. The top of the Table Mountain series is seen on the left of the picture as a long slope with one slight protuberance; the lowest part of the ridge, at a spot above which some more distant hills appear, is formed by the lowest shales of the Bokkeveld, that also occupy the flat valley in which the road lies; the higher groups of sandstone beds in the Bokkeveld series make ridges on the horizon, but the fourth sandstone is very slightly marked; the high mountain on the right is the outlier of Witteberg beds named Tafel Berg. Plate V., taken at Riet River in the Cold Bokkeveld, illustrates the succession on the east side of the Cederberg anticline; in the foreground is the Table Mountain sandstone dipping east under the Bokkeveld of the high hills (Blink Berg) in the middle of the picture, which are capped by the Witteberg beds. The top of these hills is about 2,000 feet above the bottom of the valley. The four groups of sandstone in the Bokkeveld series appear as kranzes on the face of Blink Berg, and the three lower ones are well seen on the sky-line. The position of the shales below the fossiliferous sandstone is almost invariably marked by a valley along which a road runs. This is the case along the Cederbergen and Cold Bokkeveld Mountains, in the Hex River Valley, in the country north of the Zwartebergen, and

Plate IV.—View in the Cold Bokkeveld showing succession from the Table Mountain sandstone of Schurfteberg (on the left) to the Witteberg beds of Tafel Berg (on the right). The ridge on the right of the foreground is the escarpment of the first or fossiliferous sandstone of the Bokkeveld beds.

PLATE V.—Blink Berg in the Cold Bokkeveld. Table Mountain sandstone in the foreground; krantzes of the Bokkeveld sandstones are seen on the slope of Blink Berg, which is crowned by the Witteberg beds.

in much of the country between the Hex River Valley and the Gouritz River Poort. The fossils in the sandstone are usually in the form of impressions left by the removal of the calcareous shells. The shells themselves are rarely seen in the rock taken from near the surface of an outcrop, but when the rock from a distance of some feet from a weathered surface is obtained, the calcite shells are often seen in it. The sandstone itself is slightly calcareous, but beds of limestone are of very rare occurrence.[1]

Above the fossiliferous sandstone is the second group of shales containing fossils, from 100 to 300 feet thick. In the Cold Bokkeveld area the second group of shales is distinguished by the presence of star-fish, but many of the species that occur in the lower group are found here also. Above them is the second sandstone, which weathers into light-coloured outcrops, differing strongly in this respect from the first or fossiliferous sandstone; it contains few fossils; *Spirifer* is occasionally abundant. The second sandstone is a thick group with many shale beds, and in the Gamka Poort section reaches a thickness of 400 feet.

The third group of shales is about 350 feet thick, the beds are often micaceous, and have thin quartzites interbedded with them; they usually contain few fossils, *Nuculites* occurs in them at the Gamka Poort. Near the Tunnel Siding on the Hex River line this group

[1] A bed of limestone was found in the Bokkeveld series in the excavation of a tunnel in the Hex River Valley. See Prosser (79), p. 49. In the Clanwilliam district a nodular lump of limestone crowded with rolled up Trilobites (Phacops and Homalonotus) has been found above the fossiliferous sandstone at Fredericks Dal.

of shales yielded *Lingula*, *Nuculites*, crinoid stems, a trilobite and *Conularia*, and also some badly preserved plant stems resembling *Lepidodendron*. The third sandstone group (100 feet) with the shales above (300 feet), as well as the fourth sandstone (100 feet) and the overlying shales (500 feet), have not been found to contain fossils other than badly preserved plant remains. These are not so well defined as the lower groups, and both the shales and sandstones are often very micaceous. The fourth shale group is taken as the uppermost of the Bokkeveld series, and the beds in it often closely resemble those belonging to the Witteberg. The division between these two series is an arbitrary one, and cannot be laid down with certainty in the absence of a clearly exposed succession from below. In the country north of the Zwartebergen, in the Cold Bokkeveld, and in the Hex River-Ladismith Karroo district, there is not much difficulty in fixing upon a boundary which is probably at one and the same horizon throughout; but south of the Langebergen the task is an impossible one, and the limits of the Witteberg beds there as laid down upon the map must be considered as only roughly correct.

Along the northern slope of the Langebergen the Bokkeveld beds are very much cleaved; the cleavage planes have a constant and high inclination to the south, while the dip of the beds is very variable in amount, and in direction is either nearly north or south, the strike of the beds being nearly east and west, parallel to the cleavage. There is usually no difficulty in distinguishing between the bedding planes and cleavage

in this district, for the sandy portions of the rock resist the weather better than the finer grained beds, and stand out more or less prominently on the hill sides. South of the Langebergen, however, especially east and south of the Robertson Division, the distinction between the two sets of divisional planes is much less marked, partly owing to the strong development of the cleavage, but partly on account of the more uniformly fine-grained nature of the rocks. Few fossils have been found in the Bokkeveld beds south of the Langebergen, probably because those contained in the slates are so much distorted by pressure that they are not easily recognisable. In the small synclines of these beds, folded in amongst the Table Mountain series in the Knysna Division, several genera have been obtained; on the Keurboom's River *Orthoceras*, *Phacops*, *Orbiculoidea*, *Leptocœlia*, *Chonetes*, *Spirifer*, *Nuculites*, *Bellerophon*, *Tentaculites* and crinoids have been found. Farther west a few characteristic species have been obtained from the Bredasdorp, Caledon and Worcester Divisions, but they are usually greatly distorted.

The distinctly finer grained nature of the Bokkeveld beds south of the Langebergen than to the north of those mountains points to the position of the shore-line of the sea in which they were deposited having crossed South Africa in a general east and west direction to the north of the area now occupied by them. It is not possible to determine the position more closely, for the northern limit of the beds is only seen in the west of Calvinia, and is there an eroded surface of great age; the denudation which swept away the in-shore portion

of the Bokkeveld beds took place in the Pre-Dwyka times, and the greater part of the northern limit is still buried beneath the Karroo formation between the Oorlog's Kloof River west of Calvinia and the submerged south-eastern portion of the folded belt off the south-east coast.

The marine fossils that occur in the lower half of the Bokkeveld series afford sufficient evidence that the rocks in which they are imbedded were deposited under the sea; and the frequent occurrence of false-bedding in the sandstones throughout the series points to deposition in shallow water. The bottom of the sea must have been slowly sinking to allow such an accumulation of shallow water sediments, although some of the shales may have been formed in deeper water. In the upper part of the Bokkeveld series no marine forms have been noticed; a few indistinct plants are the only fossils that have been found in them. It is difficult to explain the absence of marine animals if the conditions under which these rocks were formed remained the same as before; and the absence of marine fossils from the succeeding 2,500 feet of the Witteberg sandstones and shales warrants the supposition that the conditions which prevailed in the area now called Cape Colony during early Bokkeveld times changed from marine to fluviatile or lacustrine after the deposition of the third shale group, and remained so throughout the later Bokkeveld and the whole of the Witteberg periods.

The following are the chief fossils from the Bokkeveld beds hitherto described:—

	Falkland Islands.	South America.	North America.	Europe.
Worm Tube—				
Serpulites sica, Salter - - - - -				
Crinoids—				
Ophiocrinus stangeri, Salter - - -				
Lamellibranchs—				
Palæoneilo antiqua, Sharpe - - -				
,, *subantiqua*, Reed - - -				
,, *rudis*, Sharpe - - -				
,, aff. *constricta*, Conrad - -			*	
,, cf. *fecunda*, Hall - - -			*	
Leda inornata, Sharpe - - - -				
Grammysia corrugata, Sharpe - - -				
Anodontopsis ? rudis, Sharpe - - -				
Orthonota, aff. *undulata*, Conrad - -			*	
Sanguinolites, sp. - - - - -				
Glossites, aff. *depressus*, Hall - - -			*	
Cardiomorpha, sp. - - - - - -				
Præcardium ? sp. - - - - - -				
Nuculites abbreviatus, Sharpe - - -				
,, *africanus*, Salter - - -				
,, *branneri*, Clarke - - -		*		
,, *capensis*, Reed - - - -				
Byssopteria ? sp. - - - - - -				
Actinopteria, aff. *boydi*, Conrad - -			*	
Modiomorpha baini, Sharpe - - -			*	
,, aff. *pimentana*, Hartt and Rathbun - - - -		*		
,, aff. *sellowi*, Clarke - -		*		
Gasteropods—				
Pleurotomaria, aff. *kayseri*, Ulrich - -		*		
Bellerophon quadrilobatus, Salter - -				
,, aff. *morganianus*, Hartt and Rathbun - - - - -		*		
,, (*Bucaniella*), aff. *trilobatus*, Sow.				*
,, ,, cf. *reissi*, Clarke -		*		
,, (*Plectonotus*), aff. *salteri*, Clarke		*		
Loxonema, sp. - - - - - - -				
Tentaculites crotalinus, Salter - - -		*		
,, *baini*, Reed - - - - -				
Littorina ? baini, Sharpe - - - -				
Theca (*Hyolithes*) *subæqualis*, Salter - -				
Conularia africana, Sharpe - - -		*		
,, *quichua*, Steinmann-Döderlein -		*		
,, cf. *undulata*, Conrad - -			*	
,, cf. *acuta*, Roemer - - -		*		

	Falkland Islands.	South America.	North America.	Europe.
Brachiopods—				
Lingula, aff. *densa*, Hall			*	
Orbiculoidea baini, Morr. and Sharpe	*	*		
Stropheodonta, cf. *concinna*, Morr. and Sharpe	*			
Strophonella, sp.		?		
Orthothetes sullivani, Morr. and Sharpe	*	?		
Chonetes falklandicus, Morr. and Sharpe	*	*		
,, cf. *coronatus*, Conrad			*	
,, cf. *arcei*, Ulrich				
,, aff. *setiger*, Hall			*	
Orthis, sp.				
Rhynchonella, sp.				
Rensselæria, sp. *a*, Reed				
,, sp. *β*, Reed				
,, sp. ?				
Trigeria gaudryi, Oehlert				*
Cryptonella baini, Morr. and Sharpe				
Spirifer orbignyi, Morr. and Sharpe	*			
,, *pedroanus*, Hartt		*		
,, *ceres*, Reed				
,, *a*, Reed				
,, *β*, Reed				
Tropidoleptus carinatus, Conrad		*	*	
Ambocœlia umbonata, Conrad				*
Retzia adrieni, de Vern				*
Rhynchospira, cf. *silveti*, Ulrich		*		
Leptocœlia flabellites, Conrad	*	*	*	
Vitulina pustulosa, Hall		*	*	
Trilobites—				
Phacops pupillus, Lake				
,, *arbuteus*, Lake				
,, *crista-galli*, Woodward				
,, *africanus*, Salter				
,, *ocellus*, Lake				
,, *impressus*, Lake				
,, (*Cryphæus*) *caffer*, Salter				
Dalmanites lunatus, Lake				
Proetus malacus, Lake				
Typhloniscus baini, Salter				
Homalonotus herscheli, Murch.				
,, *quernus*, Lake				
,, *colossus*, Lake				
Cephalopods—				
Orthoceras, two species				

The fossils[1] common to the Bokkeveld beds and the Devonian strata of the Falkland Islands, South and North America and Europe are marked with an asterisk under the columns referring to those countries. In the case of the many species which have close affinity to foreign forms (aff.) or are closely comparable to them (cf.), the asterisk refers to the locality of the allied species; many of these may be determined with certainty in the future. The fauna as a whole is more nearly related to that of the Devonian rocks of other countries than to any other, although there seems to be no evidence to correlate the Cape fossiliferous beds with any one part of the Devonian system as developed in Europe or North America. Of the Brachiopods, Mr. Reed writes, "they have a completely Devonian stamp; and there are none which suggest the presence of Silurian or Carboniferous beds".[2] Imperfect though the list of fossils given above is, it shows that the Bokkeveld fauna is much more closely related to the American Devonian fauna than to that of Europe, and more closely to the South American than to the North, in spite of the fact that the rocks of South America and the Falkland Islands are less well known than those of North America and Europe.

The country occupied by the Bokkeveld beds north of the Langebergen and in the Worcester and Robertson Divisions south of that range is characterised by strongly

[1] For descriptions and figures of the fossils the student must refer to the appendices to Bain (54) by Salter and Sharpe, Woodward (73), and Reed (04). Before long the Trilobites, Lamellibranchs, Gasteropods, Pteropods and some Cephalopods will be described and figured in the Annals of the South African Museum.

[2] Reed, *op. cit.*, p. 186.

marked escarpments and valleys, so that from the top of a prominent hill in a suitable position the lie of the rocks can be made out over a very wide area. The most accessible of such hills are the Brand Vley Mountain near Worcester, Gydo Berg north of Ceres, the high hill near Triangle, in the Hex River Valley, and the top of the hill east of the north entrance to Seven Weeks' Poort. The last-named spot is one of the finest points of vantage in the Colony for the purpose of seeing the structure of a wide area. The folds into which the rocks have been thrown north of the Zwartebergen are distinctly seen, the outcrop of the four groups of sandstone in the Bokkeveld series make independent escarpments or ledges on large ridges, and where repeated by folding the structure is seen clearly. The gradual dying out of the folds northwards in the Karroo is displayed as if the country were a geological model, and the outcrops of each formation are at once recognised. The sandstones and quartzites of the Bokkeveld and Witteberg series stand up prominently between the shale bands that have determined the positions of the minor valleys, the soft, easily eroded shales having offered an easier path for the rivers than the more resistant sandstones. The view is limited on the north by the great dolerite-crowned escarpment of the Nieuweveld, seventy miles distant.

South of the Langebergen the structure of the country is not at all obvious until it has been made out in detail, for the Bokkeveld beds have been cut to a level with the outliers of the Uitenhage series; and although this plain has since been dissected by rivers, the Bokkeveld and Witteberg slates, on account of their uniform char-

acter, have had little effect in determining the positions of the valleys, so that the longitudinal valleys so conspicuous north of the mountains are not nearly so well developed to the south.

The Bokkeveld beds do not furnish any stone or minerals of much economic value. The sandstones are used for making walls round kraals and camps, and to a small extent for house-building on farms. Their colour is too dark and patchy, and as a rule they are too fissile and difficult to work to be used when any other building materials are obtainable.

The country occupied by this series is generally well populated, for the soil is rich. The shales break down into good soil, so the positions of the thicker bands of shale are usually marked by lands and gardens, often with a dip slope of the Table Mountain sandstone on the one hand and an escarpment of the Bokkeveld sandstones on the other.

Springs are more numerous along the junction of the Table Mountain sandstone and the Bokkeveld beds than elsewhere in the neighbourhood, and although many of the springs yield "kruit water," *i.e.*, water with the smell of sulphuretted hydrogen, due to the mutual decomposition of pyrites and the organic matter in the shales in the presence of moisture, they are very valuable sources of water. This peculiarity of the water is the cause of so many farms being called "Stink Fontein," a name that recurs again and again on the Bokkeveld areas as well as on other rocks, such as the Dwyka and Ecca beds, the water from which has frequently the same characteristic.

The Witteberg Series.

The Witteberg series consists of sandstones, quartzites, and shales. The sandstones and quartzites are in thicker groups than those of the Bokkeveld beds, and occasionally contain thin beds of white quartz pebbles, and also isolated pebbles of the same material. The resemblance between the Witteberg quartzites and the Table Mountain beds was the cause of much confusion in the early days of Cape Geology, but it is more apparent than real. The Witteberg quartzites, as a whole, have a more reddish and yellow tint and are more micaceous than the Table Mountain rock, and they are much less massive, shale bands being of comparatively frequent occurrence. The shales are green, dark grey and blue in colour, and they are often very micaceous and sandy, frequently being more properly called thin, irregularly bedded micaceous sandstones than shales. In the Eastern Province there are black carbonaceous shales, which are different from any beds in this series that have been found in the west. The Witteberg beds have so far yielded no remains of animals, and only rather poor specimens of plants which have not been satisfactorily determined for want of good material.

The following genera of plants have been mentioned [1] as having been found in the Witteberg beds :—

[1] This list except the last genus is taken from Feistmantel (89), pp. 25 and 26, where references to the original authorities may be found. I have omitted those said to occur at Tulbagh, for a mistake has evidently been made in the locality, or it is insufficiently defined.

Selaginites	Port Alfred.
Lepidodendron	Grahamstown, Swellendam and Riversdale.
Lepidostrobus	Port Alfred.
Halonica	"
Knorria	Swellendam.
Sigillaria	Port Alfred.
Stigmaria	"
Cyclostigma	Many places in the west of the Colony.

Little value can be set upon the determinations in the above list, but it is of interest to note that all the genera occur in the carboniferous rocks of Europe, and the *Cyclostigma* is very like a fossil described by Feistmantel from the Goonoo Goonoo beds (Devonian or Carboniferous) of New South Wales.

By far the most abundant fossil, if it be one, is *Spirophyton*, but Mr. Seward,[1] who has examined some of the specimens collected by the Cape Survey, is of opinion that these markings are not of organic origin. *Spirophyton* is found as an impression extending spirally through several inches of rock, with the curved striations radiating from a central depression to a peripheral groove. It is difficult to understand how such a well-defined structure with a sharply marked limit passing spirally through several layers of sediment can be produced by mechanical means, such as the swirling of water through a hole in the sand. No carbonised remains of vegetable matter have been found adhering to the surface of the *Spirophyton* impressions, but the same is the case with the undoubted plant impressions from the Witteberg and Bokkeveld beds in the west of the Colony. There is a great area of Witteberg beds in

[1] Seward (03).

the east that has hardly yet been examined for fossils, and as one of the varieties of plant impressions is there found preserved with some coaly matter adhering to the specimens some fresh evidence of the nature of *Spirophyton* may be expected in the future.

Whether a true fossil or not, *Spirophyton* has been found of great service in enabling the Witteberg beds to be recognised, as it is doubtful whether it occurs in the uppermost Bokkeveld beds, and it has never been found in the Dwyka or later rocks. It is met with in hard quartzites and in shales, the best specimens are those from the quartzites; the markings are better preserved in quartzite than in the micaceous and sandy shales, although they are more abundant in the latter.

The Witteberg beds have a maximum thickness of about 2,500 feet. They form several important ranges of mountains on the southern border of the Karroo, and their name is taken from the Wittebergen, south of Matjes Fontein. In the west and south of the Colony the mountains composed of the Witteberg beds are remarkably bare and barren-looking (see Plate VI.). They are less well supplied with rain than the Table Mountain sandstone ranges, for the latter are generally higher and therefore receive a heavier rainfall. The high percentage of quartz sand in the Witteberg beds causes the soils derived from them to be poor and thin. The formation is first met with in the west of the Colony, north of Eland's Vley (Calvinia and Clanwilliam), where the long line of hills called the Zwart Ruggens commences. The northern boundary is a denuded one, and, as is the case with the Bokkeveld boundary a little farther to the

PLATE VI.—An anticline in the Witteberg beds at Tyger Fontein in Prince Albert.

north, is of great antiquity, being chiefly older than the Dwyka series. Following the Witteberg beds southwards they become thicker owing to the coming in of higher and higher beds below the Dwyka. Some outliers, somewhat table-shaped mountains, are found at Bidouw, Gerustheid, and in the angle between the Bosch and Doorn Rivers in the north-east of Clanwilliam and south-west of Calvinia. The Zwart Ruggens are a long dip slope of the quartzites on the east of the Cederberg and Cold Bokkeveld anticlines. When seen from the Karroo the Zwart Ruggens appear to consist entirely of whitish quartzites, for the numerous shale bands are more easily weathered away and can only be seen when one enters a ravine or gorge, such as the Tra-Tra or Winkelhaak's (Doorn) River valleys, which drain the Cold Bokkeveld. The Zwart Ruggens merge into the Bonteberg Range at Karroo Poort, when the strike of the rocks changes from south to east. The axis of the Bonteberg anticline is inclined eastwards, so that the Dwyka series sends a tongue west-south-west towards Pienaar's Kloof north of Touw's River Station. The Witteberg beds are continued across Pienaar's Kloof into the Voetpad Berg, and also round the south of the Quarrie Kloof Dwyka outlier into the Wittebergen. In the southern part of the Worcester Division the Witteberg beds form a V-shaped area; the two arms of the V meet on the south and are cut off by the Worcester fault to the north, but the western junction is buried beneath the conglomerates of the Uitenhage series; the apex of the V is at Roode Berg near the road between Villiersdorp and Worcester. In Robertson the Witte-

berg beds form an area about twenty-four miles in length, south of the fault; and they also occur in Swellendam and Riversdale. To the north-east of Montague they form two synclines connected at the eastern end; Klein Berg is part of the southern syncline, and the hills near Dobbel Aars Kloof belong to the northern one.

Between the Bonteberg and Matjes Kop these beds cover a considerable area, over forty miles long and twenty wide in places, being thrown into many small folds, and in four of the synclines or troughs outliers of the Dwyka series occur; the Nauga and Coega (or Kouga) hills are in this area. The axis of the main anticline of the Wittebergen disappears eastwards south of Laingsburg, where a long syncline of the Dwyka series lies south of the eastern part of the range. The Witteberg beds pass round the western end of the Dwyka syncline into Eland's Berg, which disappears eastwards in a similar manner to the Wittebergen, but the beds pass round another westerly rising Dwyka syncline into the long range of foot hills north of the Zwartebergen, and extend far to the east, certainly as far as Willowmore; they reappear from under a syncline of the Dwyka series in the Groot River and Klein Winterhoek ranges to the north. East of the Klein Winterhoek Mountains the Witteberg beds form the Zuurbergen, the hills near Commadagga, Botha's hill and the hills south of Grahamstown, and much of the country between Grahamstown and the coast.

The Witteberg country in the Eastern Province is much better covered with vegetation than that in the west, chiefly on account of the greater rainfall, but pos-

sibly the eastern rocks are somewhat more argillaceous and less quartzitic than the western, and therefore give rise to better soils. Whether the Witteberg series as a whole becomes finer grained towards the east is still uncertain, for it has not been closely examined in that part of the country.

In the south of the Colony east of Robertson the Witteberg beds are distinctly less quartzose and coarse grained than to the north of the Langebergen; a similar change takes place in them to that noted in the case of the Bokkeveld series, as they are followed southwards. It has been stated previously that the absence of marine fossils, or rather the remains of animals that are evidently related to forms which only live in the sea, from the Witteberg beds must be regarded as evidence that these sediments were not laid down under the sea, but they may have been formed in fresh water. The settlement of this question must always be a difficult task, and the rocks must be known in much greater detail than they are at present before it can be accomplished. False bedding and rippled surfaces are frequently seen in these rocks, which were certainly laid down in shallow water not far from the land.

There can be little doubt that the Witteberg beds once extended over the whole of the southern and western portion of the Colony. The position of the coastline of the land from which the sediments were derived is as problematical as the position of the Bokkeveld coast line. From the fact that the coarse sediments are found in the northern exposures, it must be concluded that the land lay in that direction,

and it probably lay rather farther south than the Bokkeveld shore.

The Witteberg beds have no economic importance. Many years ago a nugget of gold was found in these rocks at Kragga Poort, near Constable, but nothing further has been found there. The presence of black coaly shales in the Witteberg series on the Kowie River led to prospecting for coal some forty years ago, but without success. A great part of the country occupied by this series is very rugged, owing to the quartzite bands standing out prominently from the general surface. The white quartzites often give rise to great bare stony dip slopes, such as those on the eastern side of the Zwart Ruggens west of the Karroo and in the mountains south of Matjes Fontein.

CHAPTER V.

THE KARROO SYSTEM.

THE beds belonging to the Karroo system cover the greater part of the Colony; from a line between Karroo Poort and the Gualana River mouth northwards to the Orange River east of Prieska these are practically the only rocks exposed at the surface, with the exception of the intrusive dolerites. Somewhat monotonous from the repeated occurrence of sandstones, shales, and mudstones, in all thousands of feet thick, and from the fact that they generally lie at so low an angle that in the absence of considerable changes of level in the surface a comparatively thin group of beds occupies a very wide area, nevertheless they are of great interest from some points of view. Perhaps their chief interest consists in the reptilian remains preserved in them, and in the similarity of their fossil plants to those found in the Gondwana system of India, in certain Australian rocks, and in beds in some other parts of the world.

There is at present no very satisfactory classification of the formation, but when its fossils have been more extensively collected with due record of localities, the present subdivision will be strengthened or sufficient grounds brought forward for a somewhat different one.

At present the system is subdivided as follows, in descending order:—

System	Series	Group	Approximate maximum thickness.	
Karroo System	Stormberg series	Volcanic group	4,000	8,200
		Cave sandstone	800	
		Red beds	1,400	
		Molteno beds	2,000	
	Beaufort series	Upper		5,000
		Middle		
		Lower		
	Ecca series	Upper beds		2,600
		Laingsburg beds		
		Lower beds		
	Dwyka series	Upper shales	600	2,300
		Conglomerate	1,000	
		Lower shales	700	
				18,100

The maximum thickness of the Karroo formation is not less than some 14,000 feet, excluding the volcanic beds, although it is of course not certain that the full thickness is now, or ever was, developed in any one locality. This great bulk of sedimentary rocks nowhere contains evidence of marine conditions having prevailed during its deposition; on the contrary, nearly all the fossils known from the Karroo beds were undoubtedly either land or fresh-water forms. The accumulation of so great a thickness of fresh-water beds is a very interesting fact, and we shall return to the subject after describing the various groups of rock in the system.

The Dwyka Series.

Everywhere round the borders of the central basin a conglomerate with very peculiar characters crops out. It is usually a blue or greenish rock, compact and fine grained, made up of small particles of sand, which under the microscope are seen to be chiefly composed of quartz and microline, with a smaller quantity of other felspars,

epidote, garnet, calcite and other minerals imbedded in mud, using that term for an argillaceous material too fine grained to be more definitely named. This sandy mud contains a vast number of boulders and pebbles of a great variety of rocks, amongst which are conglomerates, quartzites, sandstones, shales, slates, marbles, jaspers, granites, gneisses, diabases, amygdaloidal lavas and serpentines.

These boulders are, as a rule, scattered irregularly through the conglomerate without any arrangement in beds. Plate VII., a photograph of the conglomerate exposed in a ravine near Prieska, gives a good idea of the manner in which the pebbles and boulders occur.

Not only is the great variety in the boulders remarkable, but the shape of a large proportion of them is peculiar. When a rock is broken up by natural causes the fragments are at first angular, their shape and size depending upon the nature of the rock and other conditions; when these angular fragments are rolled along by a stream, or thrown and dragged about on a shore, the corners are worn off, and the boulders become rounded or oval in shape according to the original form of the pieces of rock. Whilst there are many boulders of this description in the Dwyka conglomerate, there are others distinctly flattened on one or more sides, with scratches of various depths on the flattened surfaces and to a smaller extent on the other parts. The striations in some cases run in one direction only across a flattened surface, but generally two or more groups of striations can be detected, or again, isolated, strongly marked and somewhat curved scratches may

Plate VII.—Dwyka conglomerate, cliff on right side of ravine about 2¼ miles from Prieska on Kenhardt road. The irregular distribution of large and small rock fragments through the sandy mudstone is characteristic. The hammer handle is 14 inches long.

be found alone or with the other striations. In all respects these boulders and pebbles are similar in form and in the nature of their striations to the scratched boulders that are found in the moraines of modern glaciers and the ancient boulder clays and moraines of Northern Europe and America, countries that are no longer so extensively covered with ice and snow as they used to be.

If the striated boulders in the Dwyka conglomerate belonged to a less remote geological period no doubt would be cast upon the glacial origin of their peculiarities; but as the rock is of Carboniferous or Permian age, an epoch so far back in the earth's history that none of the species then inhabiting the world has survived to the present day, when whole classes of animals and plants now flourishing in every quarter of the globe, such as birds, mammals and flowering plants, were still merely future possibilities, and when not one of the great mountain chains of our present day continents had come into existence, people have been very reluctant to accept this explanation. There is a deep-seated prejudice against the idea that glacial conditions could have prevailed so long ago in countries that now enjoy temperate and subtropical climates. This feeling is perhaps no longer so strong as it was in the sixties of last century, when ice-action was first brought forward in explanation of certain features in the Talchir conglomerates at the base of the Indian Gondwana system,[1] and when Sutherland[2] showed that the conglomerate

[1] H. F. and W. T. Blanford and W. Theobald, *Mem. G. S. India*, vol. i., 1859, pp. 33-90.

[2] Sutherland (68), p. 17, etc.

at the base of the coal-bearing rocks of Natal, which he stated was the same as Bain's "claystone-porphyry" in Cape Colony, was mainly of glacial origin.[1] A paper by Professor Edgeworth David on the evidences of glacial action in Australia in Permo-carboniferous time seems to have brought many European geologists to believe that such climatic conditions prevailed at so early a period.[2] The evidence does not merely depend upon the presence of flattened and striated boulders, but the general nature of much of the conglomerate and the form of the floor beneath it in certain areas confirm the glacial theory.

An ordinary conglomerate is more or less bedded, the larger boulders lie together with a small quantity of sand between them, and the pebbles likewise are roughly arranged according to size with a larger proportion of sand. The inclusions often touch one another; they are not scattered at wide intervals through the fine-grained matrix of the rock. Such conglomerates can be seen in many parts of the Colony. The Table Mountain series in the Olifant's River Mountains, at Baboon Point, and at other places on the west coast contain thick beds of conglomerate with normal characters. The Uitenhage beds in the south-western districts contain numerous instances, and at the base of the series in the Uitenhage Division there is a strongly developed conglomerate of the usual type. Amongst

[1] I have omitted all reference to the earlier views as to the origin of the conglomerate. A full historical account of this matter will be found in Corstorphine, *Geol. Comm.* (99), pp. 5-20.

[2] *Q. J. G. S.*, 1896, p. 289.

the recent deposits of the southern and western parts of the Colony, both river-formed and beach conglomerates are not infrequent. In all of these rocks one looks in vain for the characteristic flattening and striations found so abundantly in the Dwyka boulders, and for the occurrence of large isolated blocks in a fine-grained matrix. The reason is that currents or waves that have sufficient power to move large blocks of stone sweep away the pebbles and sand from the same neighbourhood, so that the large stones come to lie together, while the smaller fragments come to rest in quieter water. When a large block is entirely surrounded by stratified mud or sand, it has been dropped there by some floating body, and of such bodies ice is by far the most important. Practically the only exception to this is the falling of blocks from volcanic explosions into ash or sand, but volcanic agencies had no part in the formation of the Dwyka conglomerate. Drifting trees and masses of vegetation can be called in to account for the presence of isolated blocks of rock in fine-grained beds from which other evidence of glacial action is absent, especially if fossil wood occurs in the same beds; but such means are out of the question when we have to deal with the repeated occurrence of large blocks in unfossiliferous beds covering wide stretches of country.

Every detailed account of icebergs met with in the Arctic and Antarctic Seas mentions blocks of rock as well as small fragments, sand and mud, contained in the ice and lying upon its surface. The ice that forms along a shore encloses a quantity of pebbles and mud,

and receives additions of both ice and rock-debris from the land side; when this breaks up and part of it drifts away, the load is carried off and dropped by the melting of the ice. By means, then, of icebergs and drifting floes, it is probable that the boulders and pebbles, as well as some of the matrix of the conglomerate in the south of the Colony reached their present positions.

It is uncertain to what extent the conglomerate in the north is a true morainal deposit, that is, one formed on land or in very shallow water at the end or bottom of glaciers or ice sheets. The internal character of a moraine may not be very different from that of a sandy clay, into which boulders have been dropped from floating ice, and it is difficult to decide which is which in the absence of well-developed bedding planes; even in morainal areas the sediments deposited in temporary lakes give rise to bedded sands and shales that may be again covered up by typical boulder clay. In the case of recently glaciated regions the original surface forms of many of the deposits can be traced, and lithological changes can often be followed up and assigned to their proper place in the history of the area; but when we have to deal with the results of a glacial period of late Carboniferous age, which have probably been buried under thousands of feet of later sediments, and which are only visible owing to the removal by denudation of these superincumbent rocks, a full explanation of the meaning of each change cannot be expected. In Prieska, the district in which the northern conglomerate has been most fully examined, exposures are by no means plentiful,

and the difficulty of arriving at a just conclusion as to its mode of formation is increased by the uncertainty of its thickness at various points, owing to the removal of the overlying beds; otherwise the horizontality of the rocks would make the district a peculiarly favourable one for observations.

With the progress of the geological work in the north much evidence will be collected as to the nature of the conglomerate at different localities, so that it may be possible to delineate areas of true moraines, of glacial lakes, and possibly of conglomerates remade from the moraines as they became submerged during the advance of the water northwards.

It is quite justifiable to regard those portions of the conglomerate resting upon a striated floor as a terminal moraine formed during the retreat of the ice, or perhaps at an earlier period, that is, as a ground moraine. A considerable portion of the northern conglomerate must be included under this head, but it is uncertain whether the whole of the conglomerate in that region was formed under quite the same conditions.

To the north of latitude 33° the conglomerate rests unconformably upon the underlying rocks, but it is by no means everywhere that one can find a glaciated floor below it. In the divisions of Hope Town and Prieska excellent examples of rounded and striated hillocks (*roches moutonnées*) have been found immediately below the conglomerate. Over thirty years ago Dr. Sutherland described somewhat similar appearances in Natal;[1]

[1] Sutherland (68), p. 17.

afterwards Mr. Dunn[1] discovered a fine striated floor below the conglomerate at the confluence of the Orange and Vaal Rivers; in later years Dr. Molengraaff[2] found a similar floor below the conglomerate in Eastern Transvaal, and the Cape Survey[3] came across the magnificent *roches moutonnées* of Prieska and Hope Town.

At Jackal's Water in Prieska the conglomerate lies upon the hard quartzites of the 'Keis series, which crop out in the form of rounded and polished surfaces covered on their northern slopes with nearly parallel groves and scratches of various lengths, lying in a north-north-east to south-south-west direction. The southern ends of the hillocks are steeper, rough and unstriated. These two sets of surfaces correspond exactly with the "tail and crag," or "stoss- and lee-sides" of the *roches moutonnées* that are met with in every region where ice has passed over hard rocks. The ice, either in the form of a glacier or a more extensive sheet, in moving over the surface ground down the underlying rock with the aid of the sand and stones contained in it; the side of a projecting mass of rock exposed to the greatest grinding, naturally that facing the point from which the ice moved, had its surface smoothed, scratched, and polished. Plates VIII. and IX. are views of the quartzite *roches moutonnées* of Jackal's Water; the second view shows the nature of the surface; the lines traversing the surface from the lower edge of the picture to the right side are due to bedding planes; other cracks are those formed along

[1] Dunn (86), p. 8. [2] Molengraaff (98), p. 103; and (01), pp. 71-74.

[3] Rogers and Schwarz (00), pp. 113-120; and *Geol. Comm.* (99), pp. 95, 96.

Plate VIII.- *Roches moutonnées* exposed by the removal of the Dwyka conglomerate (in foreground) from the 'Keis quartzites at Jackal's Water, Prieska. The low hill behind the smooth surfaces is covered with angular quartzites broken from the 'Keis beds by the weather.

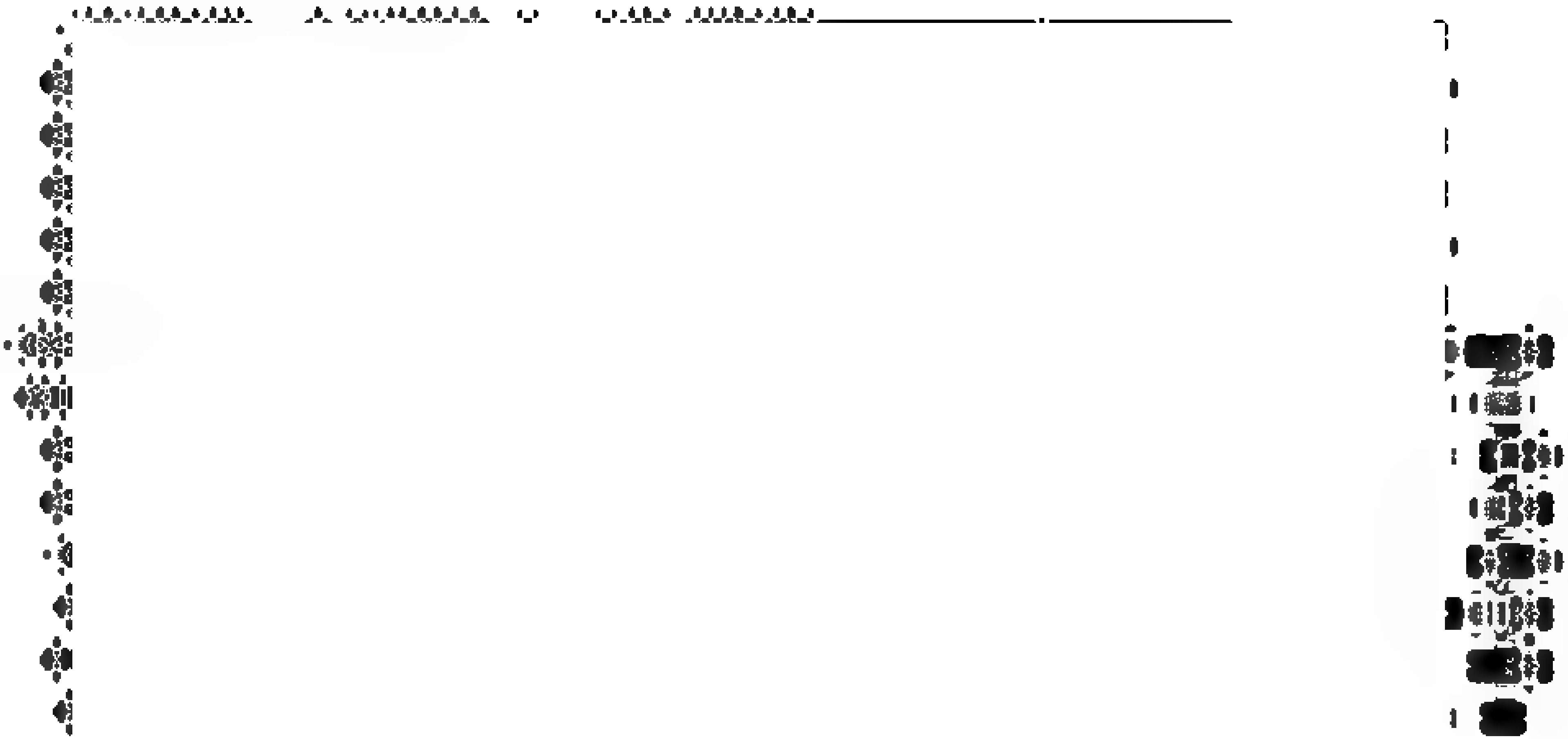


Plate IX.—Near view of one of the glaciated surfaces at Jackal's Water, Prieska. The fine striations passing obliquely across the surface and cutting the bedding-planes at a sharp angle are the glacial scratches. The bed-planes cause the cracks stretching from the right edge to the bottom of the picture.

joints; the fine striæ making a sharp angle with the bedding planes are glacial scratches.

At Vilet's Kuil, in Hope Town, the hard lavas of the Beer Vley volcanic group play a similar *rôle* to that of the quartzites of Jackal's Water, and the scratches are directed about 10° east of south, the lee-side being on the south. In both of these cases the surface of the older rock retains the *roche moutonnée* form for a distance of some 200 feet from the outcrop of the Dwyka conglomerate. Beyond this limit the rocks have lost their glaciated surfaces owing to weathering since the removal of the overlying conglomerate by denudation. The ground occupied by the conglomerate round the *roches moutonnées*, seen in the foreground of the view in Plate VIII., is covered with the characteristically striated boulders; many of these lie upon the surface of the older rocks, exposed in the immediate neighbourhood, having been left there on the removal of the matrix of the conglomerate.

The hard quartzites of the 'Keis series, and the almost equally hard lava of the Beer Vley group, are well fitted to retain the glacial markings for long periods. The reason why such phenomena are not more generally seen in Prieska is partly that many of the rocks lying below the conglomerate disintegrate rather readily, and are consequently not well adapted for preserving their old glaciated surfaces. A great part of the boundary between the conglomerate and older rocks passes over coarse granite and gneiss, which break up rapidly under the influence of great differences in temperature, a marked character of the climate in that region. Other

parts of the conglomerate boundary are hidden under sand and other surface accumulations. In addition to these hindrances to the observation of the surface that immediately underlies the conglomerate in the north, it must be remembered that but a very small part of the country has been closely examined, and that the whole tract between the Kaaing Bult and Loeries Fontein, a distance of at least 200 miles along the Dwyka outcrop, has not been touched.

The discovery of glaciated surfaces at the junction of the Orange and Vaal Rivers, in the Eastern Transvaal, in Natal, and in Prieska and Hope Town, in all over a very wide area, is sufficient to make one expect to find such surfaces below the conglomerate wherever it rests unconformably upon the older rocks. The conglomerate is unconformable north of Karroo Poort. Between Karroo Poort and the Bosch River in the Tanqua Karroo it rests upon the Witteberg beds; at two or three spots only along this part of the boundary, sixty miles in length, has the actual contact been seen, and although the surface of the Witteberg quartzites is striated at those places, there are so many slickensided surfaces in the same rocks, produced by the bending, and consequent slipping of one layer over another, after the Dwyka conglomerate was formed, that in the absence of favourable exposures it is impossible to be certain of the glacial origin of the scratches immediately below the conglomerate. The thin-bedded quartzites are ill suited for retaining the striæ, if they were ever present. Also at the time when the conglomerate was formed the Witteberg beds had only recently been deposited, and

must have been very much softer and less coherent than now after they have been buried under a great load of other rocks, subjected to earth movements, and again exposed to our view.

Between Bosch River and Matjes Fontein on the Oorlog's Kloof River, a distance of fifty miles, the conglomerate rests upon the Bokkeveld series, gradually coming to lie upon lower and lower beds belonging to that group, till at Matjes Fontein only the lowest band of fossiliferous shales remains between the conglomerate and the Table Mountain sandstone. From the Oorlog's Kloof River, where the conglomerate and sandstone crop out within a few yards of one another in the river bed, to the escarpment on the south side of the Doorn River (Calvinia) Valley, the conglomerate rests directly upon the Table Mountain series, which decreases in thickness from perhaps 5,000 feet to two or three in the interval; north and east of Uithoek the sandstone no longer intervenes between the conglomerate and the Pre-Cape rocks. The conglomerate there lies upon the Ibiquas series as far north as the fault separating the latter from Bushmanland granite and gneiss. North of the fault the conglomerate rests upon the granite (see Plate X.), and is not in the least affected by the great dislocation, which was therefore in its present state in Dwyka times.

The only place along the western outcrop of the Dwyka conglomerate where actual evidence of the movement of ice over a floor of any kind has been seen is at Eland's Vley, near the confluence of the Tanqua and Doorn (Clanwilliam) Rivers. On either side of the

Plate X.—Escarpment of the Dwyka conglomerate near Ibiquas River, Calvinia. The rock in the foreground is the Bushmanland granite.

Doorn River there is exposed a "striated pavement," not of the underlying rock, but of the conglomerate itself, which passes under a further thickness of conglomerate. The "pavement" is a flat surface of conglomerate in which there are numerous boulders up to three feet in diameter; these are pressed down flush with the general surface of the pavement, and are finely striated in one direction, which is nearly due east; these boulders may also have another set of their striæ which run in different directions, but they have been mostly obliterated by the agency that produced those mentioned. The matrix of the conglomerate is a tough blue sandy mudstone, and is traversed by numerous furrows which run parallel to the dominant striæ on the boulders. There can be little doubt that this surface, which is from fifty to eighty feet above the base of the conglomerate, was caused by ice moving across it from west to east. The conglomerate was at the time a stiff, sandy mud containing many pebbles and boulders, which, when at or near the surface, were forced down flush with the latter, and striated and polished by the sand and stones set in the bottom of the ice, that also made the furrows in the mud. After this mass of ice had disappeared, sandy mud with boulders and pebbles, precisely like the conglomerate below, was deposited upon the striated pavement. Many instances of such surfaces have been found in recently glaciated regions; they are produced wherever a glacier or large sheet of ice moves over a floor of boulder clay or till.

Where the Dwyka conglomerate first appears on the coast of Pondoland near St. John's it is faulted down

against the great block of Table Mountain beds that forms the mountain through which the St. John's River flows just before entering the sea. To the north-east of St. John's, along the western flank of the high plateau of Table Mountain sandstone that borders the coast, the conglomerate rests directly upon the sandstone, as is also the case in Natal; no part of the Bokkeveld or Witteberg series has been left in those regions between the two formations, which stand in the same relation to one another as in Calvinia, north of the Oorlog's Kloof River. The conglomerate in Pondoland has precisely the same general appearance as in Calvinia and the western Karroo; the colour and nature of the matrix are the same, and in both districts there are large and small inclusions of many varieties of rock, considerable numbers of which are flattened and striated on one or more sides.

The boulders in the Pondoland outcrops are, as usual, derived from many kinds of granite, gneiss, diabase and other igneous rocks, as well as sandstones, quartzites and other sedimentaries; but the jaspers and banded magnetic rocks from the Griqua Town beds, which form a small but interesting part of the boulders in the west and south, have not been noticed there.

A considerable part of the conglomerate is unbedded; not only are the pebbles and boulders scattered at random throughout the rock, but the matrix is without lamination planes. But in any district where the conglomerate is well exposed over large areas, traces of bedding can be found in the matrix, and it is sometimes so well laminated that it can be called a shale. In

Prieska shaly portions of the rock are found quite close to outcrops in which no lamination can be seen. Within a short distance of the spot at which the photograph reproduced in Plate VII. was taken, there is a patch of shale without any pebbles in it, and in other parts of the district the matrix of the conglomerate is well laminated. In the western and southern Karroo shaly conglomerate is often met with, the pebbles and boulders in it being precisely of the same nature as those in the unbedded conglomerate, and they occur in the same way. These shales must have been deposited in quiet water and the boulders dropped to the bottom from floating ice.

In the Tanqua Karroo a fairly constant band of very large boulders stretches for many miles north and south of Eland's Vley. It is about fifteen feet thick and some of the boulders are from three to four feet in diameter, but most of them are less than half this size; many are well striated. The rocks above and below the boulder bed differ from it only in the smaller proportion of inclusions distributed through them. Another definite boulder bed has been found in the valley of the Witteberg's River south of Laingsburg, and is shown on Plate XI. The largest block seen in the photograph is ten feet across.

Throughout the area in which there is an unconformity below the Dwyka series, the conglomerate lies directly upon the older rocks, except perhaps where small patches of shale occur, such as the one mentioned from Prieska, which may be at the base of the series. In the south of the Karroo, where the Dwyka series lies conformably upon the Witteberg beds, there is always a certain thickness of greenish shales between the conglomerate and

the Witteberg quartzites. These shales pass gradually upwards into the conglomerate, which contains only small pebbles near its base in the southern region. Although they are undoubtedly passage beds between the two formations, *i.e.*, they represent the period of transition from the conditions under which the Witteberg series was formed, to the colder conditions that prevailed later, they are placed for convenience with the conglomerate, and are called the Lower Dwyka shales. They consist of shales and thin quartzitic sandstones, and are in all from 600 to 700 feet thick, measured from the uppermost thick quartzite of the Witteberg group to the lowest bed that is distinctly conglomeratic. Some of the strata are very like the shales of the Witteberg, and others, especially near the top, are of the same nature as the matrix of the conglomerate. The Lower Dwyka shales are well exposed at many places on the north flank of the hills formed by the Witteberg series along the southern edge of the Karroo. They can be well seen south of Matjes Fontein, in the Witteberg's River south of Laingsburg, at the north end of the Buffel's River Poort (Leeuw Kloof Poort), and just south of Prince Albert village where the road to the Zwartberg Pass enters the narrow kloof, to mention some of the more accessible localities in the Karroo. East of Prince Albert this horizon has not yet been described, but at Grahamstown, both to the north and south of the town, similar shales 650 feet thick intervene between the Witteberg quartzites and the Dwyka conglomerate, lying conformably to both. There can be little doubt,

therefore, that the Lower shales are a definite group of beds present at the base of the Dwyka series wherever it lies conformably upon the Witteberg beds.

In the Witteberg's River the Lower shales have been found to contain impressions of stems resembling the *Phyllotheca* stems of the Ecca beds; these are the only known fossils from the Lower shales.

It is unfortunate that the strip of country immediately north of Karroo Poort occupied by these shales is so obscured by gravels and sand that the exact manner of their disappearance has not been determined. On the view of their relationships adopted here the break in the succession should commence at the bottom of the shales.

The Dwyka conglomerate in the south of the Colony is in some respects very different in appearance from that in the north, owing to the earth movements that have affected the former region. Throughout the southern outcrops the conglomerate is a hard blue rock from which the pebbles do not readily break out. When the rock is struck with a hammer the fracture is more likely to pass through a pebble than round it. There is a rough cleavage developed in the matrix, parallel to the strike of the beds, but at various angles to their dip. This causes the conglomerate to weather into lenticular slabs, very characteristic of the rock in the southern parts of the Colony. The slab or tombstone-structure, as the late Professor Green called it, is shown on Plate XI., a view of the steeply dipping conglomerate cut through by the Witteberg's River south of Laingsburg. The appearance resembles more closely that known as

...ulders, Witteberg s
...base of the cliff) is
...joints; the inclined
...leavage.

"pillow-structure" in many basic lavas of Palæozoic age in Britain than the normal results of cleavage. In the Karroo outside Karroo Poort, where the Dwyka conglomerate has been affected by the pressures that produced the east and west folds (Zwartberg folds), and those that gave rise to the north and south folds (Cederberg folds), the rock has the rough cleavage developed in two directions, and weathers out in pillars, usually tapering upwards. The development of the slab-structure becomes weaker as the conglomerate is followed northwards from Karroo Poort into the region where the folding did not take place, and in Calvinia the rock is of the same nature as in Prieska, a sandy mudstone or shale, according to whether lamination is absent or present. The northern rock breaks up readily, and the pebbles can easily be removed from the matrix.

A curious feature in both the northern and southern conglomerates, but more highly developed in the latter, is the regular and close jointing of the enclosed pebbles and boulders. A pebble, four inches long, may be traversed by two or three dozen joints parallel to one another, and quite independent of the original divisional planes, such as those of bedding or foliation, in the pebble. In the north and north-west, where the conglomerate lies nearly horizontally, the joints are also horizontal, but occasionally vertical ones can be found. In the south the joints, which are parallel in all the pebbles at any one spot, lie more or less parallel with the strike, but not with the bedding planes in the conglomerate. Occasionally one or more of the sections into which the pebbles are divided have shifted rela-

tively to those above and below. The matrix of the conglomerate shows no signs of the continuation of the joints through it. The jointing has been explained, on the supposition that there are faint divisions in the matrix, due to the long-continued action of a moderate pressure and solution deforming the constituent grains along the directions of the supposed planes in the matrix, so that the pebble eventually broke along these planes of deformation.[1]

At several places in the south and west of the Karroo beds and lenticular patches of white quartzite occur in the conglomerate. Near Matjes Fontein several large lenticles of quartzite lie on the same horizon. They are roughly bedded, and the bedding planes have a similar dip to that of the conglomerate in the immediate neighbourhood. In the Ceres Karroo near Beukes Fontein, there are also several quartzite lenticles like those at Matjes Fontein, but the quartzite is rather yellower, and at its periphery it contains boulders. The base of the conglomerate on the left bank of the Doorn River at Eland's Vley is very quartzitic in places, doubtless owing to the large amount of quartz sand derived locally from the Witteberg beds. Boulders of several kinds of rock, diabase, granite, etc., as well as quartzites that may have come from the Witteberg beds, are imbedded in the conglomerate there. The lenticular patches must have had a different origin, for they are considerably above the base of the conglomerate, and they occur where the Lower Dwyka shales intervene

[1] Schwarz (03), p. 399, etc. On Plate V., Fig. 2, accompanying this paper a photograph of one of the jointed pebbles is reproduced.

between the conglomerate and the Witteberg group. They are surrounded by blue rock of the normal type, and probably represent local patches of sand, but an entirely satisfactory explanation of them has not yet been found.

Some patches of the conglomerate contain more carbonate of lime than others, and weather out from the rest of the rock in the form of spheroidal and lens-shaped lumps, that occasionally pass into masses large enough to be called lenticular beds. In the western Karroo there are many such calcareous beds. The spherical lumps are usually from six to ten inches in diameter; they seem to be particularly abundant near Laingsburg and in the Tanqua Karroo, but they have been found in many other districts. The carbonate of lime in these concretions has probably reached its present position by a slow process of concentration from the surrounding rock. The matrix of the conglomerate always contains a certain amount of calcite in the form of mud, sand and small limestone pebbles.

The sources of the many varieties of rocks forming boulders in the conglomerate are only partially known. The brown, red, yellow and black banded jaspers and magnetic quartzites are identical in character with rocks belonging to the Griqua Town series in Prieska and Griqualand West. There are two kinds of amygdaloidal lavas widely distributed throughout the conglomerate in the Colony, a more basic variety like those at Zeekoe Baard, and a more acid rock closely resembling the Beer Vley lavas. Both these types are probably widely distributed in Griqualand West, so that it is im-

possible to determine the precise source of the boulders. The cherty crystalline limestones of the Campbell Rand beds have furnished many fragments to the conglomerate in the western Karroo, although they are by no means confined to that region; the Campbell Rand marbles probably supplied most of the calcareous mud so abundant in the matrix. The microline granites and gneisses, of which many varieties occur in the conglomerate, may be matched by rocks from several known outcrops in Prieska, and similar rocks seem to be abundant north of the Orange River. The Matsáp beds (purple quartzites, grits and conglomerates), are well represented in the western and southern Karroo, and so are the 'Keis quartzites and mica schists. Serpentines, found in the conglomerate west of Calvinia, are as yet only known in place in the north and north-west of the Colony. There are large numbers of white quartzite and brown sandstone boulders in the conglomerate, but their origin is uncertain; they may have come from the Table Mountain and Bokkeveld series north of the unconformity, but no Bokkeveld fossils have yet been found in the conglomerate. Many altered doleritic rocks from the southern conglomerate can be matched from outcrops in Prieska. Several well-marked varieties of acid porphyritic and felsitic rocks are met with in the conglomerate, but their source is not yet known.

The bulk of the formations that have supplied the boulders of recognisable origin occur only in the north of the Colony, and have not been met with in the south, although the latter is by far the better known area.

The microline granites are the only rocks amongst the Dwyka boulders that resemble at all closely some of the southern Pre-Cape rocks, and even they are still more like the northern granites. There can be no doubt that the main source of the boulders lay to the north, a conclusion that is in full accord with the observed direction of the striæ on the Jackal's Water and Vilet's Kuil *roches moutonnées*, as well as on the striated floor described by Mr. Dunn at the junction of the Orange and Vaal Rivers. It is also in agreement with the general relationship of the conglomerate to the underlying rocks, for the boulders came from the north where the unconformity is; there is no clear evidence that any of them had a southern origin, and so far as is known the conglomerate was laid down conformably to the Cape formation throughout the south of the Colony.

The conglomerate is about 1,000 feet thick in the south of the Karroo, but diminishes in thickness northwards. Where it lies nearly horizontally, as in Prieska, Kenhardt and Calvinia, it covers wide stretches of country, but is of varying thickness, and never more than some 500 feet, if so much. At Kimberley it is represented by a few feet of rock passed through by the shafts outside the diamond pipes.

No fossils have yet been found in the Dwyka conglomerate within the Colony, but outside our area, at Vereeniging, the remains of many varieties of plants occur at a short distance above the conglomerate, and some fragments of plants as well as layers of coal are found in the shaly rocks interbedded with boulder beds

that Mr. Dunn[1] has shown to be representatives of the Dwyka conglomerate.

Lying above the conglomerate in the south and west there are some 500 to 600 feet of shales, sandstones and cherts, called the Upper Dwyka shales, into which the conglomerate passes conformably by the gradual diminution of the number of boulders. The lowest beds are bluish or greenish sandy shales, overlain by thin sandstones, which are in their turn succeeded by a group of black shales weathering white on exposure to the air. The black shales are overlain by fine-grained green beds, with thin beds of limestone and ferruginous rocks, and several layers of chert, grey or black when freshly broken, but with a thin white crust on exposed surfaces. The uppermost of the chert beds, usually from eight to twelve inches thick, is taken as the top of the Dwyka series.

The black shales contain a certain amount of carbonate of lime, often gathered together in the form of nodules, and iron pyrites. These two minerals, and the carbonaceous matter that gives the black colour to the shales, decompose under the influence of the air, forming gypsum (sulphate of lime) and iron oxides, and leave the shales bleached white. These white rocks make very conspicuous features on the southern and western borders of the Karroo, where the vegetation is not sufficiently abundant to hide the colour of the bare hillsides. Thus the black shales near the top of the Dwyka series are known as the "white band".

[1] *Dunn* (00), p. 67.

The dark colour of these shales has led to their being prospected for coal at many places, but although the percentage of carbonaceous matter rises to 7½ per cent. nothing that can fairly be called coal has been found in them in Cape Colony.

Although the Upper Dwyka shales as a whole appear to change in character in the north of the Colony, especially by the absence of the ferruginous beds and the chert, the black shales persist in the north of Calvinia, Prieska and Hope Town, and probably across the intervening country. They exist at Kimberley, where they form part of the rocks called the "Kimberley shales," and are probably directly continuous with the coal-bearing rocks of Vereeniging that overlie and are interbedded with the boulder beds there. Mr. Dunn in 1886 [1] came to the conclusion that these shales, which he showed would certainly be found to extend under the whole of the Karroo, contain coal in some parts of that area; in 1899 when he found that the Vereeniging coal [2] lay on about the same horizon, *i.e.*, close above the Dwyka conglomerate, he naturally considered his case for the existence of sub-Karroo coal greatly strengthened. Vereeniging, and the other localities, such as Kroonstadt, where coal of inferior quality to that of Vereeniging is said to have been struck, lie far to the north-east of the black shale outcrops south of the Orange River, and nearer the old land on which the plants grew that went to form the coal, if indeed the plants did not live in the immediate neighbourhood of the present coal beds. The

[1] Dunn (86). [2] Dunn (00).

fact remains that so far as the black shales have been investigated, they contain smaller quantities of organic matter as they are followed south-west, and there is no reason to suppose that the horizon which has been proved to be without coal at many places south and west of the Karroo basin, as well as along the Hope Town-Calvinia edge, should contain valuable deposits under De Aar or any other spot within the basin where it is hidden from view beneath hundreds or thousands of feet of other beds. The places where the Upper Dwyka shales have been closely examined throughout their whole thickness and have been found to be without coal are the following, taken in order round the Karroo basin from Kimberley: Kimberley, Hope Town, the south of Prieska, Loeries Fontein, several spots west of Calvinia, Blaauw Kranz on the Calvinia transport road, the Tanqua Valley, outside Karroo Poort, Laingsburg, Prince Albert, north of Botha's Hill, Grahamstown, and again in Pondoland.

It should be remarked also, as will be more fully shown on a subsequent page, that the present position of the shale outcrop in the Prieska-Kimberley region is by no means coincident with the original limit of the group, for an outlier which has been disconnected from the main area of the beds by denudation exists far to the north-west in the Kalahari Desert.

In the banks of the Camdini River near Loeries Fontein the black shales are very well exposed, and they are traversed by dykes of dolerite, which has brought about the formation of graphite in minute scales, filling cracks in the immediate vicinity of the igneous rock.

The only recorded and determinable fossil from the Upper Dwyka shales in the Colony is *Mesosaurus*,[1] a small reptile of which only a few specimens have been found. The first specimen came from an unknown locality in Griqualand West, and was described by Gervais [2] under the name of *Mesosaurus tenuidens;* others were subsequently found in the black shales close above the Dwyka conglomerate in the Kimberley Mine, although these were too imperfect to be named with certainty. Another specimen of the genus has been found in the Upper Dwyka shales west of Calvinia; and in a very similar rock in southern Bushmanland a fine tail and hind part of the body was discovered a few years ago. All these specimens are impressions left in shale by the removal of the animal's bones.

The occurrence of *Gangamopteris cyclopteroides* var. *attenuata* Feistm. and *Noeggerathiopsis hislopi* Feistm. near Kimberley has been recorded,[3] but it is not certain whether these plants came from the Dwyka series or the Ecca.

In the south of the Colony the only organic remains yet met with in the Upper Dwyka shales are indeterminable markings that are probably of vegetable origin.

The distribution of the Dwyka series can be seen at a glance on the geological map of the Colony. It forms a continuous band round the south and west of the Karroo, then turns eastwards and passes through

[1] Another genus, *Ditrochosaurus*, has been described, but its distinction from *Mesosau us* may be due to an accidental feature in the single specimen known.

[2] Gervais (79).

[3] Moulle (85); Feistmantel (89).

Calvinia, Kenhardt, Prieska and Hope Town, where it is crossed by the Orange River, and is continued past Kimberley into the Orange River Colony and the Transvaal. North-east of that part of the coast where the sea has breached the edge of the Karroo basin the conglomerate appears again in Pondoland, and is continued through Natal to the Eastern Transvaal. Throughout this immense area the conglomerate is probably everywhere present at the base of the Karroo formation, and it has a persistent, though varying dip towards the interior, so that it forms a basin. Westwards from the Gualana River as far as Karroo Poort, and thence to the Tanqua River, the beds often dip at high angles beneath the Karroo, but farther north and east they lie horizontally, or dip at a very low angle towards the south or east. This basin whose edge is defined by the conglomerate is due to folding, but the gentle inclination of the extreme northern portion may be an original feature; the southern portion has been thrown into its present form by folding, and no evidence of the original southern limit is known.

The outliers of the Dwyka series in the folded belt south of the Karroo are few in number. The chief one is that which forms a semicircular area between Worcester and Lange Vley near Robertson. It, together with a considerable thickness of Ecca beds, is faulted down against the Malmesbury beds and granite exposed under the Langebergen. The rocks are of precisely the same general character as those along the south of the Karroo, but the black shales have been converted into graphitic slates, which have been

unsuccessfully prospected for graphite. In the Worcester district as in the Karroo the conglomerate rests upon the Lower shales, and these again lie conformably upon the Witteberg beds. The Worcester outlier is about forty miles distant from the nearest part of the main Dwyka area in the Karroo, and is particularly interesting because it shows no sign of a change in the nature of the beds or in the relationship between them and the older rocks. These facts, together with the uniform character of the conglomerate and its mode of occurrence, at least as far east as Grahamstown, warrant the assumption that the area of deposit of the Dwyka series was not limited in a southerly direction within the boundaries of the Colony.

An outlier of the Dwyka beds has been found at the head of the Winkelhaak's River in the Cold Bokkeveld. In the country south of the Karroo there are six other outliers. The largest is that of Quarrie Kloof between Touw's River and Constable stations, and four others lie to the south-east of it; the sixth is in Dobbel Aar's Kloof, about thirty miles from the Quarrie Kloof outlier. All these patches of Dwyka are boat-shaped synclines preserved from denudation by the fact that they lie in rather deep folds. The rocks composing them do not require special description, for in all respects they resemble the southern Karroo outcrops.

In the Eastern Province the outcrops of the Dwyka series are repeated by folding, as shown on the map at the commencement of the volume, but their distribution is not yet known in detail. In the Albany Division the conglomerate, with the Lower Dwyka shales, occupies

the valley in which Grahamstown is situated, and is well exposed at many places near the town. The series there lies in a syncline; the Witteberg beds dip under it both to the north (south flank of Botha's Hill) and to the south; it is also well seen north of Botha's Hill near the road to Fort Brown, on the north of the Botha's Hill anticline.

During the past year Dr. Nobbs of the Cape Agricultural Department visited the Kalahari Desert north of Upington and brought back some specimens of the formation underlying the desert sands near Eenzamheid and the Noro Kei Pan. Those from the former place are spheroidal masses of Dwyka conglomerate, just like the calcareous concretionary masses that occur in thousands in the conglomerate of the western Karroo; and from the Noro Kei Pan came pieces of silicified wood resembling that found in the Ecca beds in many parts of the Colony. These discoveries and Dr. Nobb's statement that grey shales containing the fossil wood are met with in wells near Noro Kei Pan, undoubtedly prove the existence of an outlier of the lower part of the Karroo formation in the Kalahari, more than 100 miles farther north-west than was formerly thought to be the case.

Towards the north the conglomerate has been found at Vryburg.

The Ecca Series.

Lying conformably upon the Upper Dwyka shales throughout the southern and western Karroo are the

shales and sandstones called the Ecca beds, a name given them by Atherstone from their occurrence in the Ecca Pass in Albany.

The strata immediately above the uppermost chert bed of the Dwyka in the south and west are usually thin flaky shales, and green shales are found above them, together with thin beds of mottled grey and green sandstone. Some of the shales near the base of the series break up into long roughly prismatic fragments after the manner of the starch of commerce. In the neighbourhood of Patata's River south of the Klein Roggeveld hard sandy beds lie immediately above the Dwyka series. The thickness of the lower portion of the Ecca beds in the south and west, in which the shales predominate, is from 1,000 to 1,200 feet, and they are succeeded by some 1,200 feet of strata in which sandstones are the chief feature. These, called the Laingsburg beds from their occurrence near the town of that name, are hard, dark-coloured, fine-grained sandstones and hard shales; they contain *Glossopteris, Schizoneura, Phyllotheca* and silicified wood. On the weathered surface the sandstones are usually yellowish, but some of the finer-grained beds break up into rounded fragments with a thin red crust. The Laingsburg beds have been traced through the country on the south and west of the Klein Roggeveld, where they form very hilly ground, as far as the left side of the Tanqua Valley; but they become much thinner in that neighbourhood, and apparently disappear, being perhaps represented by shales farther north. The sandstones in the Laingsburg beds often contain spherical

nodules of harder material, which stand out prominently on weathered surfaces.

The uppermost portion of the Ecca beds in the southern and western Karroo varies considerably in the proportions of sandstones and shales in different localities. The sandstones are frequently mottled grey and blue. On the Kraai River, near Tuin Plaats, *Glossopteris*, *Gangamopteris* and *Schizoneura* occur in hard shales belonging to these beds.

In the Roggeveld and Hantam region the sandstones that are so conspicuous in the country farther south are but slightly developed, and the whole of the Ecca series becomes an essentially argillaceous group, with only thin beds of sandstone intercalated with the shales; the thickness of the series diminishes in the same direction, and is probably somewhat over 2,000 feet near Calvinia village. The rocks are well exposed on the Hantam Mountains and on the Roggeveld escarpment, of which the former were once a part, having been detached from the main mass by the erosion due to the Oorlog's Kloof River.

Little is known about the Ecca beds between the Hantam and Prieska where they are probably represented by shales and thin sandstones. They cover wide areas in Hope Town, Britstown, and other districts both to the south and north of the Orange River.

The beds that are called Kimberley shales[1] and Olive shales[2] in that region probably belong in part to the

[1] Green (88). [2] Stow (74).

Ecca group, but the demarcation of the latter from the Upper Dwyka shales is not so distinct as in the south of the Colony, and the Kimberley shales are not yet known in detail. *Glossopteris, Gangamopteris* and *Noeggerothiopsis* have been described from them, and they also contain silicified wood, resembling that from the Laingsburg beds and other parts of the Ecca series.

In describing the geology of the Colony I have tried to refrain from going into details concerning particular views that have been discredited by the fuller knowledge of the country gained during the past decade, but in the case of the late Professor Green's ideas as to the relationship of the Kimberley shales and the Ecca beds a departure must be made from this practice. Green's paper[1] is perhaps the most widely known description of the geology of the Colony, and no other work on the subject approaches it in completeness or lucidity of style in spite of its short length. Its author spent some four months only in the Colony, and much of that time was occupied in an examination of the coal beds of the Stormberg, so that misconceptions regarding the wider questions are hardly to be wondered at. On pages 262-264 he argues that the Kimberley shales are a group of beds lying between the Karroo beds (the Beaufort series of the classification here employed) and the Ecca, and that they lie conformably below the Beaufort beds and unconformably upon the Ecca. In the first place he doubts Dunn's correlation of the conglomerate below the Kimberley shales with the

[1] *Q. J. G. S.*, 1888.

Dwyka conglomerate of the south; but there can no longer be any doubt on this point, the confirmation of which he admitted would greatly strengthen Dunn's classification of the Kimberley shales with the Ecca beds of the south. The presence of *Mesosaurus* in the Upper Dwyka shales of Calvinia which are directly continuous with the shales below the Ecca beds in the south, and the presence of *Gangamopteris* and *Glossopteris* in the Ecca beds of the Tanqua Valley and of Worcester certainly support the view adopted by Dunn, for these three genera occur in the Kimberley shales. In tracing the Ecca beds from the Prince Albert and Laingsburg districts through the Karroo to Calvinia, a work that has only recently been completed by the geological survey, it became obvious that the sandstones characteristic of the series in the south give place to shales north of the Tanqua Valley. It is true, on the other hand, that there are sandstones of considerable thickness in the Upper Dwyka shales along the Camdini River west of Loeries Fontein somewhat below the horizon of the black shales that weather white; the sandstones of Hope Town mentioned by Green on page 263 of his paper, and regarded by him as evidence of the occurrence of the typical Ecca beds below the Kimberley shales, almost certainly belong to the upper division of the Dwyka series. The country between Blaney and Kei Road, and the tract between Beaufort West and the Nieuweveld escarpment, which from their general characters led Green to see in them a confirmation of his view that the Kimberley shales lay between the Beaufort beds and the Ecca, are certainly

composed of the strata called Karroo beds by him and now included in the Beaufort series. They lie well above the true Ecca beds, and are separated by thousands of feet of strata from the Dwyka conglomerate, for the Ecca beds themselves lie conformably below them and upon the Dwyka series.

The Kimberley shales must be regarded as the equivalents of the Upper Dwyka shales and part of the Ecca beds of the south and west, but whether they represent the whole or only a portion of the Ecca group remains to be ascertained, for the stratigraphical details of the country between the Prieska and Hope Town Divisions and the Nieuweveld have not been worked out.

In Pondoland the Umsikaba beds occur just above the black shales of the Dwyka series. They are of considerable but unknown thickness, and differ in character from the typical Ecca beds of the west, they consist more of clays and mudstones than of shales and sandstones. Near their base, as seen on the road to Lusikisiki from St. John's and near the Embotyi mouth, they are better laminated than higher up in the group; the surfaces of the laminæ are frequently spotted with circular rusty markings about the size of a shilling, perhaps due to the decomposition of iron pyrites distributed more or less uniformly through them. Above these shales come the clays and mudstones, occasionally sandy, dark blue in colour. On the south of the St. John's fault, along which the Dwyka and Ecca beds are let down against the Table Mountain sandstone, the Umsikaba beds are harder and more like the Ecca of the west than in other parts of Pondoland. At Cape Hermes some thin shales

contain obscure plant remains reminding one of the *Schizoneura* stems of the west. The Umsikaba beds are found from Libode to Bizana, but have not been followed south-west of Libode.

The junction with the overlying Idutywa beds is apparently a conformable one, but ill defined, as the passage is very gradual. The Idutywa beds consist of rather loose sandstones weathering to a light yellow colour, interbedded with blue and purple shales. They perhaps correspond to the upper part of the Ecca or the lower portion of the Beaufort series, possibly both. No fossils have yet been found in them.

In the Worcester District the Ecca beds are faulted down against the Pre-Cape rocks between a point some four miles west of the town of Worcester and the Goree River, and again near Robertson. The beds are green and brown argillaceous sandstones and shales and mudstones, sometimes coloured green and red. From the sandstones and mudstones exposed in a small quarry near Worcester station specimens of *Gangamopteris*, *Glossopteris*, and *Cardiocárpus* have been found; the last-named genus is not known elsewhere in the Colony although it occurs at Vereeniging; *Schizoneura* occurs in a quarry west of Worcester.

The list of fossils from the Ecca beds in the Colony is very short, but it is augmented if we go beyond our boundary to Vereeniging, where Mr. Leslie has made large collections which have been described by Mr. Seward[1]. The following is a list of the plants known from these beds up to the present time:—

[1] Seward (03), pp. 78-101.

Cape Colony.	Vereeniging.
Schizoneura.	*Schizoneura.*
Phyllotheca.	*Phyllotheca.*
Cardiocarpus.	*Cardiocarpus.*
Glossopteris browniana, Brongn.	*Conites.*
Gangamopteris cyclopteroides var. *attenuata*, Feistm.	*Glossopteris browniana*, Brongn.
Noeggerathiopsis hislopi, Feistm.	*Gangamopteris cyclopteroides*, Feistm.
	Sphenopteris.
	Psygmophyllum kidstoni, Sew.
	Sigillaria brardi, Brongn.
	Bothrodendron leslii, Sew.
	Noeggerathiopsis hislopi, Bunb.

This assemblage of plants has a close relationship to the flora of the lower part of the Gondwana system in India, from the Talchir to the Damuda beds.[1] The genera *Glossopteris, Gangamopteris, Noeggerathiopsis, Schizoneura, Phyllotheca*, and *Sphenopteris* are common to the two groups of beds; the *Glossopteris* flora, as it is called, is also found in the Lower Coal Measures and the Newcastle or Upper Coal Measures of New South Wales,[2] the Bacchus Marsh sandstones of Victoria,[3] the Bowen River formation of Queensland,[4] the Lower coal bearing rocks of Tasmania, in Brazil and in the Argentine Republic (Bajo de Velis beds)[5]. In Queensland[6] marine beds with numerous fossils of Permo-carboniferous type have been found interbedded with those containing the *Glossopteris* flora, and in Russia a few characteristic

[1] *Manual of the Geology of India*, 2nd edition, Oldham.

[2] Feistmantel (90).

[3] Jack and Etheridge (92).

[4] Jack and Etheridge (92), p. 70.

[5] Kurtz, *Revista del Museo de la Plata*, vi., p. 117. In English in *Records, G. S. I.*, xxviii., p. 111.

[6] Jack and Etheridge (92), p. 70.

...ds containing ...eds also con-

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...herefore, more ...an the Ecca.

[1] ...

Glossopteris itself has a very great time range, probably from the Carboniferous to Upper Cretaceous,[1] but it is the most characteristic genus in the flora named after it; it is usually confined to the lower portion of the long range of beds referred to above.

The mingling of the northern carboniferous genera, *Sigillaria*, *Psygmophyllum* and *Bothrodendron* with the *Glossopteris* flora at Vereeniging[2] is of considerable interest on account of the almost complete absence of the northern forms in India and Australia, although in Brazil the northern and southern genera are again found together. It has been suggested that the cold climate of the south at that time, as evidenced by the glacial conglomerates in Africa, India and Australia at or near the base of the strata containing the *Glossopteris* flora, will explain the absence of the northern carboniferous plants; but it must be remembered that there is no reason, so far as South Africa is concerned, to believe that the cold climate was of longer duration than the time represented by the Dwyka series, for no conglomerates or isolated blocks of stone have been found in the Ecca or Beaufort beds of Cape Colony; both *Glossopteris* and *Schizoneura* extend upwards into the Beaufort series, and the latter genus occurs in the Stormberg group. The thickness of the strata above the Dwyka series from the Ecca to Stormberg inclusive is about 12,000 feet, and throughout this great mass of rocks no evidence of glaciation has been seen, so that the northern flora could

[1] In desert sandstone of Queensland, Jack and Etheridge (92), p. 528.

[2] Seward, *Address to Bot. Sect. Brit. Ass.* (03), pp. 8-13; *Ann. S. A. Museum* (03), pp. 99-101.

hardly have been kept out by the severity of the climate. Moreover, the *Sigillaria* and other northern genera have only been found at Vereeniging, where they are closely associated with glacial boulder beds, and they appear to be absent from the southern Ecca beds.

The Beaufort Series.

In the western districts there is a gradual passage upwards from the Ecca beds, and those that succeed them contain the remains of *Pareiasaurus* and other reptiles.

The Beaufort beds get their name from their occurrence in Beaufort West and the Fort Beaufort Division. They consist of sandstones, shales and mudstones. The sandstones are of two kinds, a rather loose-grained rock that forms thick bands of strata in the Nieuweveld area, often giving rise to plateaux and smaller terraces on the slopes of the Nieuweveld, and a finer-grained rock that is in thinner beds and often weathers with a red crust. The first variety is called "defining sandstone," [1] and the second "intermediate sandstone," on account of the usual relative positions of the two rocks in the plateau caps and in the slope between the terraces respectively. This difference in position is due to the weather-resisting qualities of the rocks ; the thick sandstones last longest, and therefore cap the larger terraces, while the intermediate sandstones make smaller ledges on the mountain sides, and shales and mudstones lie between them. The sandstones are often false-bedded, and may have their surfaces ripple-marked. The shales

[1] Schwarz, *Geol. Comm.* (96), p. 15.

and mudstones are usually dark-blue or greenish in colour, but thin beds of purple and red shale are not infrequent.

In the more argillaceous beds of the Beaufort series there are concretionary nodules and lenticular layers of blue-black limestone often containing small veins and pipe-like rods of chalcedony, white or pink in colour. The rods are occasionally branched, and seem to be due to the silicification of small roots. Both the limestone and chalcedony are often found permeating the large fossil bones of *Pareiasaurus*, or other reptiles, and are certainly closely connected in their origin with the presence of organic matter, just as is the case with the flints in the chalk of Europe. Very rarely small bivalve shells have been found inside the limestone nodules in the Beaufort beds. In many of the flat areas in the Karroo, where a considerable thickness of shale or mudstone has been weathered away, the ground is strewn with large numbers of the nodules. On the outside they have a peculiarly roughened surface, from which the veins and other forms of chalcedony stand out prominently. The nodules can be seen near any of the railway stations between Groot Fontein and Beaufort West; they are like the Ecca nodules, but the latter do not contain chalcedony. Both the nodules and the thin lenticular beds have been formed by the concentration of the carbonate of lime, distributed generally through the sediments, since the latter were laid down. Beds of clay-pellet conglomerate are frequently met with at the base of the sandstone bands in this series, and less frequently in the Ecca beds. The clay-pellet conglomer-

ate is a rock with a shale or mudstone matrix containing numerous rounded or flattened lumps of mud rather different in colour from the matrix, but otherwise of much the same nature. At places the matrix is more sandy than usual, and the mud-pellets are in consequence more conspicuous, for they weather away more readily than the rest of the rock. The lumps of mud were derived from previously deposited sediment, and were rolled along by the current till they came to rest where they are found. In many rivers which vary in level, either daily on account of the tide, or at irregular periods owing to varying rainfall, mud-pellets may be seen on the muddy or sandy bottom exposed at times of low water. The tidal lagoons of the Eastern Province rivers, and the lower part of the Olifant's River (Van Rhyn's Dorp), are good places for the observation of mud-pellets due to daily changes of water-level, and the Orange River, near Prieska, has many sandy stretches along its banks exposed during dry seasons and covered with mud-pellets brought down by the last flood. There is no doubt that mud flats, exposed at the surface of a shallow lake or sea, would furnish lumps of mud to the small waves washing their margins, and it is probable that the clay-pellet conglomerates in the Karroo formation were formed in this way. Possibly the deposited silt could become tenacious enough to resist complete disintegration without being exposed to the air, and yielded the pellets to currents that were stronger than usual sweeping through the shallower parts of the basin.

Local unconformities affecting the beds over small areas, sometimes only a few yards wide, are very abund-

ant in the Beaufort and Ecca beds. The lower lying strata are cut off by the upper to the depth of, perhaps, four or five feet, usually less, and the higher beds thicken out to occupy the depression made in the lower. These hollows are usually in shales or mudstone, and the rocks filling the hollows are sandstones or clay-pellet conglomerates. The frequency of these examples of "contemporaneous erosion and deposit" point to the deposition of the strata in quite shallow water which from time to time received sudden accessions from rain floods, or possibly also had strong streams developed in it by a constant wind.

The clay-pellet conglomerates in the Beaufort series frequently contain rolled pieces of bone. Pebbles of rock are very rare both in the conglomerates and the other strata, and the few that have been found do not reach a length of two inches.

Coal has been found in thin layers in the Beaufort beds. Behind the Komsberg escarpment on the farm Lange Kuil a nine inch seam of bright coal occurs, but it is unsuitable for burning under ordinary conditions, as it crumbles immediately one attempts to make a fire with it owing to its large content of water. This coal has a small percentage of ash, 6·8 per cent. It occurs in beds containing large fragments of bone, probably of *Pareiasaurus*. Vague reports are sometimes forthcoming of coal near the base of the Nieuweveld, in the highest part of the Gouph, and also in the *Pareiasaurus* beds further south. Nothing has yet come of these reports, although the country is one that is very easy to prospect in owing to the extensive exposures of the rocks. High

up in the Nieuweveld escarpment at Leeuw River Poort, and also in the Camdeboo, there are some remarkable vertical cracks filled with bright bituminous coal.[1] The Leeuw River Poort fissure is over 300 feet deep, and varies in width from twelve feet downwards. The fissure does not maintain a straight course, but at places runs horizontally or at a low angle. It passes through a few thin horizontal seams in a band of sandstone, but the thickest seam is about an inch thick. The coal is remarkably free from ash, an analysis giving only ·8 per cent. The fissure seems to have been produced during the intrusion of the dolerite sheets which occur on the Nieuweveld, and the bituminous coal was probably partly squeezed and partly distilled into it at the same time. Although slickensided surfaces in the coal near the edges of the crack prove a slight movement to have taken place after its formation, there is no appreciable vertical displacement of the rock outside the fissure. The coal at Buffel's Kloof, Camdeboo, occurs in a similar manner, and no seam worth working has been met with there. Thus although there is coal in the Beaufort beds it has not yet been found in sufficient quantity to work. The reports of coal at Tamboer's and Ongeluk's Fonteins in the Gouph, and at Lett's Kraal at Graaff Reinet are based upon the occurrence of carbonised wood in fragments.

The base of the Beaufort beds is the lowest stratum containing the remains of *Pareiasaurus* or other reptiles given in the list below. Where these are absent, as in

[1] Dunn (79); Schwarz, *Geol. Comm.* (97), p. 24; and for a similar occurrence in East Griqualand, *Geol. Comm.* (03), p. 16.

the western part of the Roggeveld, the Klein Roggeveld, and, so far as we know, in the country north of Fraserburg and Victoria West, some other means have to be devised for separating this series from the Ecca. In the Moordenaar's Karroo and Klein Roggeveld a bed of red weathering sandstone has been taken as the base, and in the Roggeveld (Fish River Valley) a thick band of sandstone different from any that occurs in the Ecca beds in the same district. The line as laid down on

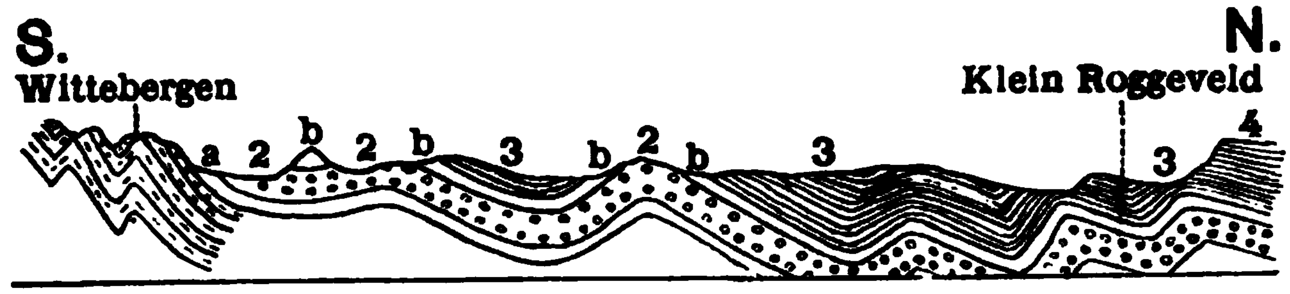


Fig. 16.—Section from the Wittebergen to the Klein Roggeveld, from the folded belt to the Karroo basin. Distance about 13 miles. Vertical scale $\frac{1}{12}$ in. to 1,000 feet.

1. Witteberg series.
2. (b) Upper shales conglomerate / (a) Lower shales } of Dwyka series.
3. Ecca series.
4. Beaufort series.

the map accompanying this volume is of little real significance except in the Great Karroo, where the boundary is fixed on palæontological grounds. The northern portion of the boundary is practically unknown. In the Eastern Province A. H. Green described an unconformity which may be at the base of the Beaufort beds near Aberdeen,[1] but there is nothing known in the west corresponding to this unconformity. On a rapid traverse through the Gouph or southern Karroo the remarkable change of dip which takes place at the south

[1] Green (83), p. 25; (88), p. 261.

of the Klein Roggeveld (see Fig. 16) and along the same line farther east may be mistaken for an unconformity, but the appearance is due to the sudden cessation of the folds north of the Zwartebergen. Pinchin[1] records a marked unconformity north of Port Elizabeth at about the same horizon as that described by Green, but farther east in the Transkei it has not been seen. The true significance of these observations must remain uncertain till the Eastern Province has been connected with the Western by means of systematic mapping.

The Beaufort series can be divided into three groups characterised by various reptilian genera, but at present the classification is not very satisfactory, especially towards the upper limit. No lithological characters distinguishing the three groups have been made out. The chief fossils and some of the localities from which they have been obtained are the following:—[2]

		Localities.
Upper Beaufort.[4]	Theriodontia[3]—	
	Cynognathus, Seeley	Lady Frere.
	Gomphognathus, Seeley	Burghersdorp.
	Microgomphodon, Seeley	Aliwal North and Burghersdorp.
	Diademodon, Seeley	Aliwal North and Burghersdorp.
	Stegocephalia—	
	Rhytidosteus, Ow.	Beersheba, Orange River Colony.
	Batrachosuchus, Br.	Aliwal North.
	Anomodontia—	
	Dicynodon latifrons, Br.	Burghersdorp and Aliwal North.

[1] Pinchin (74), pl. iv.

[2] I have to thank Professor R. Broom for correcting this list and for giving me the classification of the reptiles. The localities as a rule refer to Divisions and not villages.

[3] For references to the literature of the Reptiles see Owen, Seeley, Huxley, Broom, Lydekker, in the Appendix.

[4] See note at end of chapter.

Middle Beaufort.

Therocephalia—	
Ælurosaurus, Ow. -	- Beaufort West.
Cynodraco, Ow. -	- Sneeuw Berg, Fort Beaufort.
Lycosaurus, Ow. -	- Kriga Berg, Fort Beaufort.
Cynosuchus, Ow. -	- Sneeuw Berg.
Cynochampsa, Ow. -	- Rhenoster Berg.
Tigrisuchus, Ow. -	- Sneeuw Berg.
Lycosuchus, Br. -	- Aberdeen and East London.
Ictidosuchus, Br. -	- Pearston.
Ictidosaurus, Br. -	- Beaufort West.
Scymnosaurus, Br. -	- Beaufort West?
Scylacosaurus, Br. -	- Beaufort West?
Scaloposaurus, Ow. -	- Sneeuw Berg.
Gorgonops, Ow. -	- Fort Beaufort.
Anomodontia—	
Dicynodon, Ow. -	- Beaufort West, Fort Beaufort, Graaff Reinet, Cradock.
Oudenodon, Ow. -	- Beaufort West, Fort Beaufort, East London, Sneeuw Berg, Graaff Reinet.
Kistecephalus, Ow. -	- Sneeuw Berg.
Endothiodon, Ow. -	- Beaufort West.
Theriognathus, Ow. -	- Sneeuw Berg.
Esoterodon, Seeley. -	- Molteno Pass, Beaufort West.
Cryptocynodon, Seeley.	- Nieuweveld.
Pristerodon, Huxley -	- East London.
Opisthoctenodon, Br. -	- Pearston and Beaufort West.
Lystrosaurus, Cope - (= *Ptychognathus*, Ow.)	- Cradock, Bethulie, Sneeuw Berg.
Theriodontia—	
Galesaurus, Ow. -	- Rhenoster Berg.
Procolophonia—	
Procolophon, Ow. -	- Tarka, Middelburg.
Lacertilia—	
Paliguana, Br. - -	- Queens Town.
Rhynchocephalia—	
Saurosternon, Huxley	- Sneeuw Berg.
Stegocephalia—	
Micropholis, Huxley	- Rhenoster Berg.
Bothriceps, Huxley -	- Orange River Colony.

Middle Beaufort—*continued.*	Fish—	
	Atherstonia, S.-Woodward	Colesberg and Fraserburg.
	Palæoniscus, Agassiz -	Sneeuw Berg.
	Lamellibranchs—	
	Palæomutela, Amalitzky -	Graaff Reinet, Bedford.
	Palæanodonta, Amalitzky	Graaff Reinet.
	Plants—	
	Schizoneura - - - -	Sutherland, Beaufort West, Bethulie, Cradock, Pearston, etc.
	Glossopteris	
Lower Beaufort.	Pareiasauria—	
	Pareiasaurus, Ow. - -	Beaufort West, Fort Beaufort, Prince Albert.
	Therocephalia—	
	Tapinocephalus, Ow. - -	Gouph.
	Titanosuchus, Ow. - -	Gouph.
	Delphinognathus, Seeley -	Prince Albert.
	Pristerognathus, Seeley -	Gouph.
	Plants—	
	Schizoneura - - - -	Beaufort West, Fort Beaufort, Sutherland.
	Glossopteris - - - -	Beaufort West, Fort Beaufort, Sutherland.

The distribution of these three divisions is only known in its barest outlines. The Lower Beaufort beds form the western part of the Roggeveld Plateau, the whole of the Klein Roggeveld, the northern part of the Moordenaar's Karroo and Gouph, and they probably stretch from Aberdeen past Somerset East, Bedford, Fort Beaufort to the coast south-west of East London, and are perhaps represented in the Transkei by the Idutywa beds.

The Middle Beaufort beds form the higher portions of the Nieuweveld, the Sneeuwbergen, the country north of the Sneeuwbergen as far as Colesberg and Bethulie, and southwards to East London, where they

range into the Transkei and are in part represented by the Idutywa beds. Of the limit between the Middle and Lower Divisions between the Nieuweveld and the Orange River nothing is known.

The Upper Beaufort beds crop out below the coal-bearing Molteno beds of the Stormberg series both to the north and south of the Stormberg region, but the details of their distribution are unknown.

The foreign equivalents of the Beaufort series can be given approximately only. In the Panchet beds of the Indian Gondwana system *Dicynodon* and *Ptychosiagum*, two Cape genera, have been found, and with them are plants belonging to the *Glossopteris* flora, especially *Glossopteris* and *Schizoneura*; in the Panchet beds there are also some genera, of which *Thinnfeldia* is the most important, that in the Colony are found only in the Stormberg group. In New South Wales the Newcastle beds may represent the Beaufort as well as the Ecca beds. Perhaps the most interesting comparison can be drawn between the Beaufort fauna and flora and those of the Permian formation of Russia. *Palæomutela* and *Palæanodonta* are two genera of probably fresh water mollusca that are common to the Russian and South African beds; of the first-named genus four species from the Karroo beds were determined by Amalitzky to be identical with Russian forms, *viz.*: *P. trigonalis*, *P. semilunata*, *P. murchisoni*, and *P. plana*, while seven other species are very closely allied to others from Russia; of *Palæanodonta* two species are common to the two formations, *P. okensis* and *subcastor*[1]. Amalitzky has

[1] Amalitzky (95), pp. 337-51.

recently[1] found *Pareiasaurus* and *Dicynodon* in lenticular beds within the Permian strata on the Dwina River that also contain *Glossopteris* and *Gangamopteris*. Both above and below the horizon on which these characteristic Karroo genera occur there are limestones containing marine species of Permian age, belonging to a stage widely developed on the continent of Europe and known as the Zechstein. These discoveries go far towards settling the age of the Beaufort beds relatively to the European rocks.

The Stormberg Series.

In the north-east of the Colony and in Basutoland there is a great area of shales and sandstones capped by volcanic rocks and broadly distinguished from the underlying Beaufort beds by the presence of a different group of fossil plants. Instead of the *Glossopteris*, which is so widely distributed through the lower rocks, the genera *Thinnfeldia* and *Tæniopteris* now appear. The name Stormberg beds was applied to these upper rocks by Wyley[2] and Huxley,[3] and it has been used by all later writers. The series is divided up into the following groups :—

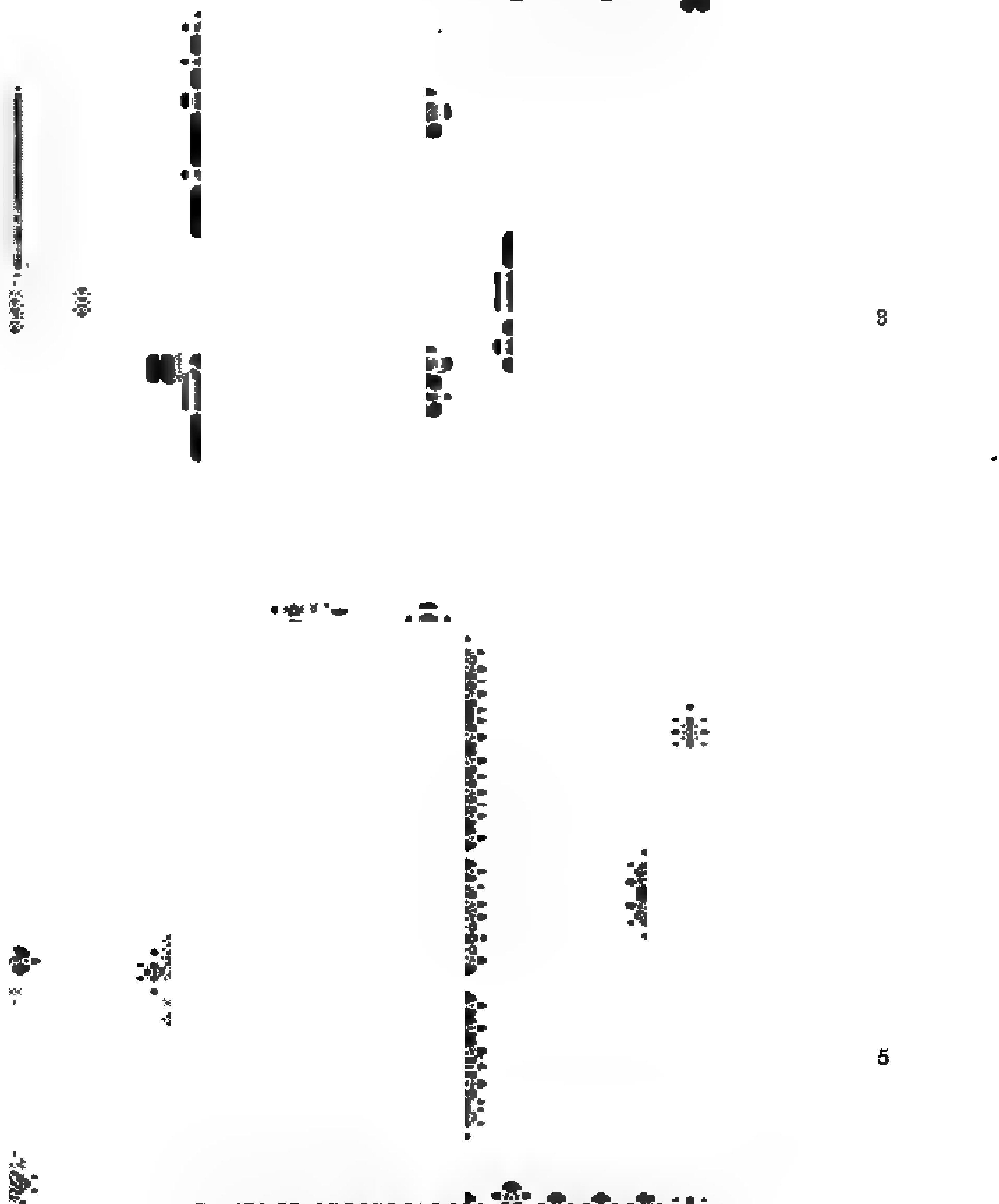
		Maximum Thickness.
Stormberg series	Volcanic beds - -	4,000 feet.
	Cave sandstone - -	800 feet.
	Red beds - - -	1,400 feet.
	Molteno beds - - -	2,000 feet.

[1] Amalitzky (00).
[2] Wyley (59), p. 61.
[3] Huxley (67), p. 5.

THE MOLTENO BEDS.

The Molteno beds form the lower slopes of the Strombergen and Drakensbergen and the country along the foot of the range. The exact position of their base has never been defined, but, as in the case of the Ecca-Beaufort junction in the west, it seems to be a gradual passage. *Glossopteris* has not yet been found in the Stormberg region, although both to the south and north the genus occurs in shaly beds on a lower horizon. Similarly *Thinnfeldia, Tæniopteris*, and *Stenopteris* are not known from the Beaufort beds. Whether a detailed examination of the passage beds will show a clearly defined junction or an intermingling of the two sets of plants remains to be seen.

The beds consist of shales, mudstones and sandstones. The shales and mudstones are very like those of the Beaufort and Ecca beds, but they do not contain the calcareous concretions so abundant in the lower groups. They are usually grey or greenish in colour, sometimes bluish purple, and in places contain abundant plant remains. The localities from which most of the fossil plants hitherto discovered in these beds were obtained are Indwe, Molteno, Cyphergat, Maclear, the Kenigha River, in Mount Fletcher and the Matatiele slopes of the Drakensberg, but as the fossils appear to be more numerous in the Molteno beds than in any of the lower beds, it is probable that they will be found to be widely distributed on both sides of the Drakensberg-Stormberg ridge. The sandstones of the Molteno beds are



[illegible] Molteno beds)

[illegible] natural size.

[illegible] size.

unlike any that occur in the lower groups of the Karroo system. In general appearance and in the character of the surface to which they give rise they resemble the Table Mountain sandstone more closely than any other in the Colony, but they are coarser in grain and looser in texture than that rock, and do not form such thick masses. In some localities the quartz grains are coated with a later deposit of quartz with more or less perfect crystalline faces which reflect light well and give to much of the rock a glittering appearance in sunlight. Felspar grains are abundant in these sandstones, as they are throughout the sandy beds in the Karroo formation, but the looser texture of the Molteno sandstones has allowed the felspar to weather considerably, and the dull white grains of weathered felspar are always conspicuous constituents of the sandstone. Rounded or spherical nodules, hollowed out in the centre when the hard outer shell has been broken through, are quite a characteristic feature of the Molteno sandstones. The hard shell is due to the addition of hydrated iron oxides to the cementing material usually present. The nodules are formed by the oxidation of pyrites and the deposition of some of the resulting iron compounds in a spherical zone about the lump of decomposed pyrites.

The finer-grained varieties of sandstone are good building stone, easily worked and of a yellow or cream colour. Fencing poles are split from the large sandstone slabs by driving in wedges along straight lines across the slab and breaking it along the rows of holes. Posts up to six feet in length are thus obtained.

The sandstones do not contain so many fossil plants

as the shales, and the fossils are less well preserved than in the latter.

Thin beds of conglomerate occur in connection with the sandstones in the Molteno area, usually with red ferruginous nodules that give the rock a characteristic appearance on the outcrop. This rock is found a short distance above coal seams in several parts of the district and is an aid in the search for coal.

Coal is found in the Molteno beds from the Stormbergen along the lower slopes of the Drakensbergen in East Griqualand as far as the Natal border, and also on the northern slope of the watershed, although it is only in the Stormberg-Indwe region that any serious work has been done on the seams. The whole area has not been surveyed yet, but the work already done in various parts is summarised here.

There seem to be two horizons on which workable coal has been found; the lower extends from Sterkstroom eastwards to Indwe, beyond Indwe towards Engcobo the coal has been followed but not worked to any extent; the upper is that to which the Molteno seams belong, and is on a horizon some hundreds of feet higher than the Indwe coal; its extent is not well known beyond the neighbourhood of Molteno, but it may be represented by some thin coal seams seen in the Cala pass some 300 feet above the Indwe coal. In the Indwe district[1] the base of the Molteno beds is taken at the bottom of a band of bright-coloured felspathic sandstone, which lies upon red, purple, and green shales and mudstones be-

[1] Du Toit, *Geol. Comm.* (03).

longing to the Beaufort series. The typical Stormberg plants have not been found in these argillaceous beds, which contain bones that have not yet been collected or described from the Indwe district, though it is not improbable that some of the reptiles from the Albert Division belong to this horizon.

Above the felspathic sandstones lie sandy shales and thin sandstones with a total thickness of some 700 feet, containing *Thinnfeldia*, *Stenopteris*, *Callipteridium*, *Tæniopteris* and *Schizoneura*. Towards the top of this group of argillaceous rocks come the Indwe coal seams. The coal seams are rarely over twelve inches in thickness, but at places several occur together, so that in a band of rock composed of coal and shale, six feet thick in all, about four feet of the whole may be coal, which has of course to be picked out from the accompanying shale before it is removed from the collieries. The number of the seams varies within short distances owing to the sandstone, which usually forms the "roof," cutting across one or more of the coal beds, a state of things that was brought about by the erosion of the coal shortly after its deposition, and which is paralleled by thousands of cases of "contemporaneous erosion and deposit" throughout the Ecca, Beaufort and Stormberg series. The coal is usually laminated and contains very thin layers of silt; it is a coal that was formed at perhaps a considerable distance from the spot where the plants that furnished the vegetable matter grew, for there is no trace of a land surface on which the coal plants grew, and the alternation of thin layers of coal and silt evidently point to the vegetable matter having been deposited over the floor of

the lake in the same manner as the silt. It is this silt that accounts for the high percentage of ash or incombustible matter in the Stormberg coals.[1]

The abundant intrusions of dolerite in the form of dykes and sheets, especially the latter, have an injurious influence on the coal. The distance through which this influence makes itself felt varies; the chief effect is the driving off of the more volatile constituents, and it culminates in the coking of the coal, which is rendered valueless.

The insertion of a few analyses of the coals, taken from the official Reports referred to on a previous page, may be of use in indicating the class of coal to which the Colonial seams belong.

	Molteno (mean).	Cyphergat.	Indwe.	Sterkstroom.	Matatiele.	Cala.
Moisture	1·13	28·24	12·54	18·26	1·37	1·50
Volatile Hydrocarbons	10·31				24·68	9·50
Fixed Carbon	60·89	50·07	63·03	51·38	47·53	68·51
Ash	28·80	21·69	24·42	30·36	25·10	19·70
Sulphur	·76				1·33	·79
Total	101·89	100·00	99·99	100·00	100·01	100·00

From the results of numerous experiments it has been concluded that the ratios 1 to 1·5 and 1 to 1·83 represent the weights of Welsh and Stormberg coals required to be burnt in order to do a given amount of work.[2] A

[1] For detailed information about the coals of this region, see Dunn (78), North (78), Green (83), Galloway (89).

[2] Galloway (89).

rock allied to torbanite (oil shale), occurs below a coal seam in Matatiele[1] and in other parts of South Africa; the following analyses, together with that of the rock from Torbane Hill in Scotland, will show the nature of the substance:—

	Natal, Upper Umzimkulu.	Matatiele.	Basutoland.	Torbane Hill.
Moisture	1·58	1·32	34·00	70·10
Volatile Hydrocarbons	16·30	18·16		
Sulphur		·89		
Coke	12·07	32·37	16·66	10·30
Ash	70·05	47·26	49·34	19·60
Total	100·00	100·00	100·00	100 00

The Red Beds.

The Molteno beds pass upwards conformably into a group of strata that is distinguished from them by its prevailing red colour. The name was first used by Mr. Dunn who described the group in the Stormberg area.[2] The Red beds have been found to extend through East Griqualand, though with varying thickness. Palæontologically they are separable from the Molteno group by almost entirely negative characters, for the comparatively rich flora known from the latter has no representatives in the higher strata so far as our present knowledge goes. Some reptilian bones, as yet undescribed, have

[1] Schwarz, *Geol. Comm.* (03), pp. 21, 22.

[2] Dunn (78). Other sources of information concerning this and the succeeding group are: Schwarz, *Geol. Comm.* (02); Du Toit, *Geol. Comm.* (03).

been found in them, but silicified wood is the only other fossil known from these rocks.

Red-coloured strata are by no means confined to this subdivision of the Stormberg series; similarly coloured rocks are found both in the Molteno beds and the Cave sandstone. The Red beds cannot be regarded as of more than local importance, and it is often difficult to decide where the boundary lines between the three groups should be drawn.

The most characteristic rocks of the Red beds are purple and red mudstones and shales, but red sandstones and thick beds of yellow and white felspathic sandstones are also present. The thick "glittering" sandstones of the Molteno beds do not occur in this group. Bands of blue or green mudstones are not uncommon. Conglomerates, though rare, are not entirely absent; the pebbles are of white quartz and quartzite.

Mr. Dunn records 600 feet of Red beds in the Stormberg area. In Elliot they reach a maximum of 1,400 feet, and in Matatiele they dwindle down to 200 feet. It is obvious that in the case of a group of rocks which cannot be very closely defined, different observers are likely to include different strata under one head, but in spite of this there is certainly a thinning out of the Red beds and of the overlying Cave sandstone towards the north-east on the East Griqualand side of the Drakensberg.

The Cave Sandstone.

The Red beds pass upwards into the Cave sandstone, as a rule without any sharp line of demarcation. The

Cave sandstone is an extraordinarily massive rock with bedding planes feebly developed. The sandstone is largely made up of quartz grains; grains of felspar (mostly microcline) are fairly abundant, and tourmaline, zircon, white mica and hornblende are also present. Generally the rock is white or grey in colour on exposed surfaces, but on a fresh fracture it has a reddish tint. Bands of red sandstone occur in this formation, and are in no way different from the sandstones of the Red beds.

In the Stormberg area the Cave sandstone is about 150 feet thick, in Elliot 800 feet, and in Matatiele it decreases again to a maximum of 130 feet. At certain places, as in the north-west of Elliot and in the northern part of Matatiele, the Cave sandstone is not present; it thins out owing to denudation which took place just before the volcanic outbursts, so that the lavas of the volcanic group rest directly upon the Red beds.

Fossils are very rare in this rock, the only finds recorded from the Colony being fragments of reptilian bones. In the Orange River Colony, however, fish (*Cleithrolepis* and *Semionotus*) have been described from the Cave sandstone of the Smithfield district.[1]

The Cave sandstone gives rise to very remarkable features on the slopes of the mountains and on the top of several spurs projecting from the main ridge. It tends to weather into huge pillars and irregularly shaped masses, often with the lower portion hollowed out to form a shallow cave, a characteristic that gave the rock its name. Such rock-shelters were frequented by bush-

[1] See note at end of chapter.

PLATE XII.—A spur of the Drakensbergen near N'qutsha's Nek. The rocks forming the lowest slopes belong to the Red beds, the white rock is the cave sandstone, and that on the summit is doleritic lava of the Volcanic group.

men, whose former presence is indicated by agate chips, fragments of ostrich shells and coarse pottery, and especially by more or less realistic sketches of men and animals done in red and black colours upon the pale surface of the rock.

Above the village of Elliot the hard yellow sandstone forms buttresses and pillars over 300 feet high. The outcrop of the Cave sandstone can easily be distinguished at a distance of many miles by its colour and broken appearance. There is no rock in the country that produces such peculiar features as the Cave sandstone where typically developed (see Plate XII.).

The Volcanic Group.

Before the close of the period represented by the Stormberg sedimentary rocks volcanic activity commenced in the north-eastern part of the Colony. From the neighbourhood of Molteno the volcanic rocks stretch far to the north-east through Basutoland and along the Natal boundary perhaps as far as the Transvaal; but very little information is as yet available on this question, and it refers to only a small proportion of the whole volcanic district.[1]

The volcanic rocks form the highest parts of the country in which they occur. The crest of the Drakensbergen is carved out of them for a great distance, and the high ridges in Basutoland that are admirably

[1] The following papers are the chief sources of information on this volcanic group: Cohen (75); Dunn (78); Churchill, (Natal) (98); Schwarz (03); Schwarz, *Geol. Comm.* (02); Du Toit, *Geol. Comm.* (03).

displayed from many points on the Matatiele border are evidently of the same nature.

On the Colonial border the volcanic rocks rarely reach 3,000 feet in thickness, but in the ridge of the Malutis (Basutoland) north of N'quatsha's Nek there must be quite 4,000 feet of them, and Mr. Churchill measured a vertical thickness of 4,500 feet on the Mont aux Sources.

By far the greater part of the group is formed by lava streams. Bedded agglomerates and tuffs are quite subordinate features in those districts that have been examined.

In the district of Elliot near the Tembu Pass there is an interesting section showing the following succession of beds from above downwards:—[1]

5	Bedded lavas - - - - -	350 feet.
4	Purple and stratified ash - - -	80 ,,
3	Cave sandstone - - - - - -	30 ,,
2	Bedded lavas - - - - - -	50 ,,
1	Cave sandstone - - - - - -	700 ,,

The lavas (No. 2) are very vesicular at the base but become doleritic a few feet from the junction with the underlying sandstone. The sandstones No. 3 pass into the volcanic ash lying above them. The lower lavas probably came from a vent exposed on the farm Mountain Cliff, and they have been traced over a mile between the two parts of the Cave sandstone. The ash beds No. 4 have been traced to a large vent on the farm Tulloch near the Barkly Pass; towards the east they thin out, and the lavas No. 5

[1] Du Toit, *Geol. Comm.* (03).

rest directly upon the Cave sandstone which is no longer divided into two portions by the lower group of lavas.

Other thin lenticular beds of ash have been found interbedded with the Cave sandstone in the Elliot Division. During his recent investigation of that area Mr. du Toit came to the conclusion that the earliest volcanic eruptions there took place under water, and that the intercalations of ash beds with the Cave sandstone represent breaks in the continuous deposition of the latter, during which its usual characters were masked by the abundance of volcanic debris.

In the western part of the Elliot volcanic area, under the Xalanga Peak, Mr. du Toit found that the lowest lavas rest upon the Cave sandstone for a certain distance and then pass downwards at a slight angle over an apparently eroded surface of that rock till they rest directly upon the Red beds. To the north-east of this locality the same geologist found a band of red sandstones and shale rather under 50 feet thick, intercalated between the two lower groups of lavas for a distance of some ten miles round the head waters of the Qokama River. The lava below the red sandstone band lies upon the Red beds. Mr. du Toit considers that this part of the country was disturbed by local earth movements at the commencement of the volcanic epoch, and that the lower portion of the Cave sandstone was removed by erosion over a certain area during the deposition of the upper portion of the same rock in other parts of the district. A band of Cave sandstone fifty feet thick occurs above the second group of lavas between the Washbank and Xalanga Peaks.

In the Stormberg area, as described by Mr. Dunn in the report referred to on a previous page, the proportion of ash beds to lavas is somewhat greater than in Elliot, and some of these beds were formed under water before the close of the Cave sandstone stage.

From the most westerly point from which the volcanic group has been described as far as the north-east of Elliot, with the exception of the western part of Elliot mentioned above, the Cave sandstone lies between it and the lower groups of the Stormberg series. In the north-eastern part of Matatiele the volcanic group again rests directly upon the Red beds over a distance of some four miles. From the evidence gathered during his survey of Matatiele Mr. Schwarz came to the conclusion that the Cave sandstone itself was partly volcanic in origin, for he obtained fragments of lava from that rock at Zureka, and the Cave sandstone appeared identical in general character and in the nature of its component minerals with the rock filling some of the volcanic vents in the same district.

In the Matatiele Division the development of true ash beds between the lava flows is very restricted. On the crest of the mountain behind the farm Eyrie there are two bands of sandstone and shale, forty and twenty feet thick respectively, intercalated between thick flows of lava. The section through the upper part of the mountain at this locality is, in downward order:—

Lavas - - - - - - - -	130 feet.
Sandstones and shales (red) - - -	20 ,,
Lavas - - - - - - - -	70 ,,
Shale - - - - - - - -	40 ,,
Lavas - - - - - - - -	630 ,,
Cave sandstone - - - - - -	100 ,,

The red sandstones consist of fragments of altered glass and other rocks of volcanic origin mixed with grains of quartz, microcline and zircon, probably derived from the same source as the materials composing the Cave sandstone. Such beds as these can be regarded as partly of ordinary detrital origin and partly volcanic, although it is of course difficult in the absence of large lumps of lava (bombs) to be certain whether the volcanic material in the rock came directly from a vent or whether it reached its present position through the ordinary agents of denudation. They undoubtedly were deposited under water, and thus support the evidence already quoted to that effect.

So far as we have information about the volcanic group in Natal tuffs are of very rare occurrence there.

The lavas[1] are basaltic in composition and vary very much in outward appearance according to their structure. The glassy varieties are amygdaloidal and usually much altered, a circumstance that makes them less conspicuous than the doleritic lavas (see Plate XII.), for they weather more rapidly and give rise to debris-covered slopes on the mountain sides rather than to krantzes. The mineral components are similar in all the varieties, though the proportions in which they are present differ. The felspar is labradorite or an allied variety as is the case in the dolerite intrusions; most of the augite is colourless and resembles that of the intrusive dolerites; olivine is often present either fresh or more or less changed to serpentine; these

[1] For descriptions of the various varieties, see Schwarz, *Geol. Comm.* (02), pp. 65-96.

three minerals are the most important constituents; magnetite is always, and apatite often present in the lavas, and occasionally a green augite. Serpentine, epidote and calcite are the usual alteration products. Glass is found in several varieties of the lavas. Mr. Schwarz lays stress upon the absence of brown mica and original hornblende from the Matatiele lavas, for these two minerals are frequently present in the intrusive dolerites, though usually in small quantities. On this ground he regards the volcanic rocks as belonging to a distinct phase of igneous activity from the dolerites so abundant throughout the central and eastern parts of the Colony.

The differences between the varieties of lava depend upon the amount of glass present and the relations of the augite and felspar to each other. The glassy lavas are basalts with a greater or less amount of glass and microcrystalline base in which lie more or less well-formed crystals of olivine, felspar and augite. The doleritic lavas may have a very small quantity of residual glass, the felspar is either in fair-sized porphyritic crystals, between which small felspar and augite crystals lie, or in smaller crystals often enclosed by ophitic masses of augite. The last-mentioned type of rock is very similar in structure to the dolerite of the thick sheets and dykes elsewhere in the Colony, and the other variety of doleritic lava is like the dolerite of the smaller sized intrusions, with the exception of the presence of brown mica and hornblende.

The amygdaloidal varieties of lava are almost entirely basalts. The steam holes have in places never been filled

in so that weathered out to the rocks they are scoriaceous. The minerals filling these cavities are calcite, chalcedony, or zeolites, amongst which heulandite, thomsonite, stilbite, and perhaps scolecite, have been recognised; a green layer of chlorite or delessite sometimes lines the cavities which have been filled in with one of the abovementioned minerals. The amygdales may be more or less spherical in shape or irregular. In certain lavas there are pipe-like amygdales, four or five inches long and often branching upwards. They are found in zones near the base of the flows, separated from the underlying rock by a few inches of compact or vesicular lava in which the steam holes are of the usual type, and they are approximately perpendicular to the floor.

In the Stormberg district, Elliot and Matatiele, the only parts of this volcanic region that have been closely surveyed, numerous necks of agglomerate and lava have been described.

Mr. Dunn describes Telemachus Kop near Molteno as a crater filled with an agglomerate of many varieties of lava and sedimentary rocks, the latter being highly altered by heat. It is certain that the crater form of this and the few other volcanic pipes which show it is due entirely to erosion and weathering long subsequent to the period of activity. He mentions in his report, or places on his maps of that region, five pipes near Molteno and Jamestown. There are sixteen volcanic necks exposed in the Elliot Division. They are at various distances up to about four miles from the main ridge of the Drakensberg, and are differently situated with regard to the surrounding beds according to their

distance from the main ridge. The necks farthest from the ridge are in the Red beds, and those nearer to it are surrounded by the Cave sandstone or the lower lavas. They vary in size from fifteen yards in diameter to an area one and a half mile long by a quarter wide (the Tulloch volcano). In some cases lava streams have been traced to a certain vent, but generally denudation has proceeded so far that the original connections have long since been destroyed, and there is consequently little evidence to indicate from which vents the great sheets of lavas, piled up to a thickness of over 2,000 feet in the Washbank peak, came.

Some of the small necks are plugged with dolerite lava, but as a rule the pipes are now filled with a bluish tuff or agglomerate containing fragments of sedimentary rocks and lavas; these tuffs weather white and sometimes look like outliers of the Cave sandstone from a distance. A large neck near the top of the Gat Berg is entirely plugged with dolerite. It is often found that the necks are partly filled by lava and partly by agglomerate.

Dykes of dolerite have traversed some of the Elliot necks, and they occasionally traverse the lava flows. In this area no great fissures through which the lavas may have reached the surface have yet been found, but a survey of the whole breadth of the volcanic band may reveal their presence.

In Matatiele Mr. Schwarz found at least nineteen distinct vents, of which only one lies on the crest of the Drakensberg; the others are all within seven miles of the highest ridge on the East Griqualand side of it.

Whether the volcanoes are confined to the high ridges of volcanic rocks, or whether they are spread broadcast over Basutoland is not yet known.

The largest of the Matatiele pipes is on the farm York, it is about a mile in diameter, and it has been cut in two by a tributary of the Mabele River. The vent is filled partly with amygdaloidal and doleritic lavas, and partly with agglomerate. The dolerite was the first rock to flow from the pipe, and it is still connected with a columnar flow of dolerite that lies upon the Cave sandstone. The doleritic rock was succeeded by amygdaloidal lavas, part of which are still preserved in the lava flows, 4,000 ft. thick, near Ongeluk's Nek. Near the volcano the lava contains large masses of sandstone and shale baked and converted into porcellanite by the heat of the lava. There are some baked shales that Mr. Schwarz regards as having been formed in temporary lakes or streams on the volcano itself, and subsequently hardened by fresh flows of lava. Brown, gritty soil is preserved between some of the lava streams that issued from this vent, indicating that the volcano, even if it started its activity below the water level, piled up its lava sufficiently to form a land surface. The agglomerate is dark blue in colour, and includes large numbers of fragments of lavas and sedimentary rocks; this material is probably the result of the final explosive outburst of the volcano. Evidence of the long duration of the activity of this vent is given by the old valleys carved out of some of the lava flows and filled in by later ones.

The smallest volcanic neck in this district is only

four yards across, but most of the others are over 100 yards in diameter. The majority are filled with agglomerate, of which the matrix is largely composed of quartz grains derived from a sedimentary rock or a granitic one, as both orthoclase and microcline are abundant; these are felspars which do not occur in the Drakensberg lavas. Zircon, rutile, hornblende, tourmaline, muscovite and garnet, all minerals that are foreign to the lavas, are also present. With these minerals occur others, plagioclase especially, that are important constituents of the lavas, of which both large and small fragments are frequently embedded in the agglomerates. Pieces of charred wood have been found in some of the agglomerates; they are the remains of trees that grew on the slopes of the volcanoes during periods of quiescence; on a renewal of activity, fragments of these trees fell into the crater, and were imbedded in the breccias composed of comminuted volcanic and sedimentary rocks.

Taking into consideration the great thickness of lavas in this portion of the Drakensberg, the absence of more normal agglomerates from the necks is certainly remarkable, and gives the vents a character somewhat similar to that of the peculiar pipes of Kimberley, Sutherland and other districts in the Colony, which will be described in a later chapter. Some of the pipes of the Kimberley type, however, contain melilite-basalt, a rock which is entirely unrepresented in the explored parts of the Stormberg volcanic series; and the age of the Kimberley type of vent is probably much later than that of the Stormberg volcanoes. None of these later pipes is known to have given exit to lavas which flowed at the surface.

Mr. Schwarz came to the conclusion that a considerable thickness of the lavas in Matatiele did not issue from the volcanoes, but came from fissures which are now filled with dolerite and are dykes traversing both the sedimentary rocks and the lower lavas. The largest of these dykes is about fifteen miles long and a mile wide at its broadest part. It runs parallel with the main ridge of the Drakensberg from Deer Park to George Moshesh's country, and on its southern side the amygdaloidal lavas cut through by it are turned upwards in a similar manner to the upturning of sedimentary beds round the walls of a volcanic neck. Along the northern wall of this dyke the lavas are much disturbed and crushed. These are features which have not been noticed in the usual dolerite dykes in the Colony; in the latter the molten rock seems to have risen quietly without having to exert a force capable of crushing or disturbing the rocks forming their walls. The formation of the dolerite-filled fissure on the Drakensberg ridge was evidently accompanied by explosive action, and through it may have been poured a large part of the lava which now builds up the higher portion of the ridge and a great bulk of rock that has disappeared under the ceaseless attack of the weather.

In no part of the Stormberg volcanic series have there been found great piles of lava and ashes arranged more or less symmetrically about a centre as are the lava streams and tuffs of such volcanoes as Vesuvius and Teneriffe, or the great flows of the Hawaian Islands; but allowance must be made for the changes wrought by denudation during the very long period, represented in other countries by the Jurassic, Cretaceous, Tertiary

and Quarternary deposits, formations that are but scantily developed in South Africa.

The absence of necks of agglomerate or other material from the Transkei beyond a narrow zone lying within a few miles of the mountain crest is certainly significant; it points to the existence of a line of weakness more or less coincident with the position of the present ridge of the Drakensberg, along which at least the chief volcanic activity prevailed. Whether this was also the case throughout the region, and whether the lines of vents or fissures of eruption are marked by the important spurs of the Drakensbergen in Basutoland which Mr. J. Orpen[1] found to be made of volcanic rocks, can only be ascertained from an examination of Basutoland.

It is quite possible that some of the larger necks mentioned on previous pages are the passages through which great quantities of materials were ejected, and that these formed volcanic cones of large size now completely swept away. A general fact which bears on this question, however, is that the great conical volcanoes of the present day consist chiefly of fragmental tuffs which thin out quickly in all directions, though they may cover very wide areas. So far as our information goes the Drakensberg volcanoes were not of this type, for there are but few beds of tuff, and the agglomerates in the necks are largely composed of non-volcanic detritus, a state of things that would hardly obtain were the Drakensberg group strictly comparable with modern

[1] The first map of the volcanic region, that attached to Professor Cohen's paper (75), was based upon information collected by Mr. Orpen.

lava and ash volcanoes, or those of Carboniferous and Devonian age in the British Islands.

It is difficult to ascertain why a region so rich in lavas is so poor in ordinary tuffs; many of the former rocks were highly vesicular, and therefore contained an abundance of water, an important factor in determining the explosive character of volcanic activity; it is also difficult to understand why so many of the necks should be largely filled with material derived from sedimentary or deep-seated igneous rocks which are very different in nature from the ejected lavas.

The part played by this volcanic episode in the geological history of the country can be more conveniently dealt with in another chapter (chapter xi.), where its relation to previous and subsequent events will be explained.

The following is a list of the fossils hitherto discovered in the Stormberg beds:—

Plants—

Schizoneura krasseri, Sew.
Strobilites.
Thinnfeldia odontopteroides, Morr.
,, *rhomboidalis*, Ett.
Cladophlebis.
Callipteridium stormbergense, Sew.
Tæniopteris carruthersi, Ten.-Woods.
Chiropteris cuneata, Carr.
,, *zeilleri*, Sew.
Baiera stormbergensis, Sew.
,, *schencki*, Feistm.
Phœnicopsis elongatus, Morr.
Stenopteris elongata, Carr.

Fish[1]—

Ceratodus kannemeyeri, Seeley.
,, *capensis*, S.-Woodward.
Dictyopyge ? draperi, S.-Woodward.
Semionotus capensis, S.-Woodward.
Cleithrolepis extoni, S.-Woodward.

Reptiles[2]—

Tritylodon longævus, Ow. (also thought to be a mammal).
Euskelesaurus, Hux. } Dinosaurs.
Massospondylus, Ow. } Dinosaurs.
Orosaurus, Hux. (*Orinosaurus*, Lyd.) } Dinosaurs.

In his discussion of the relations of the Stormberg plants with those of foreign rocks, Mr. Seward[3] came to the conclusion that they are allied to the Rhætic flora of other parts of the world. This flora had a more general distribution than the earlier one characterised by *Glossopteris* and *Gangamopteris* in the southern hemisphere, and by *Lepidodendron, Sigillaria*, and *Cordaites* in the northern, for it has been found in Europe, Asia, Australia, North and South America and South Africa.

Several of the most striking genera in the Stormberg flora, however, are by no means confined to this series, but occur in either newer or older beds. In the Cape Colony, for instance, species of *Tæniopteris, Sphenopteris* and *Cladophlebis* have been found in the Uitenhage series, and *Schizoneura* in the Beaufort and Ecca beds.

In India the Upper Gondwana beds have yielded many forms that occur in the Stormberg beds. The Panchet beds contain *Thinnfeldia odontopteroides* and *Schizoneura gondwanensis*, to which some Cape specimens are very

[1] See note at end of chapter. [2] Owen (76), (84); Huxley (67).
[3] Seward (03).

similar. The Panchet fossils, however, are, on the whole, more nearly allied to those from the Beaufort series, as in addition to *Glossopteris*, *Dicynodon* and *Ptychosiagum* have been obtained from them. The Rajmahal beds contain plants allied to those of the Stormberg series and also to the Uitenhage flora. The Kota Maleri beds contain a species of *Ceratodus* like *C. capensis* from the Stormberg beds of Smithfield, and also *Massospondylus*.

In Australia the genera *Sphenopteris*, *Thinnfeldia*, and *Tæniopteris* are known from the Hawkesbury-Wianamatta beds of New South Wales, from the lower "Trias-Jura" (Burrum) and Ipswich formations of Queensland, and from the Upper Coal-bearing series of Tasmania. The Hawkesbury series also contains *Cleithrolepis*, *Dictyopyge*, and *Atherstonia*, the two former being Stormberg and the latter a Beaufort species.

Any attempt to draw close parallels between these distant strata is foredoomed to failure; but the results of a comparison on broad lines are sufficiently striking, and hold out the prospect of a more detailed correlation in the future when the fossils are better known. The greater part of the correlation of the African, Indian and Australian rocks rests upon the plants which seem to be far less satisfactory than the remains of invertebrates which furnish the means of correlating so many formations in distant parts of the world. The reason for this is twofold; in the first place fossil plants are too often badly preserved and at the same time the variation amongst individuals of one species is great, so that their determination allows wide latitude of opinion; in the second place the number of species that can be used

for the purpose is comparatively small. In time these difficulties will be partly overcome, but meanwhile any evidence from better preserved and more highly organised forms of life, such as fish and reptiles, deserves more credit than that from the plants. Unfortunately fish and reptiles are decidedly rare in the formations that may have been contemporaneous with our Karroo system, though the recent discoveries in Russia referred to in connection with the Beaufort series lead one to expect much more help from the reptiles than we now have. Many species and even genera of reptiles are founded on very fragmentary remains, and too much weight cannot be put on determinations founded on pieces of the skeleton in the absence of the skulls.

The question of the general bearing of the Karroo rocks upon the geological history of the country will be dealt with in chapter xi.

We may notice here that there is no indication of the sea having invaded the Karroo region during the period of deposition of these rocks. None of the numerous Carboniferous, Permian, or Triassic marine shells known from Europe and Asia have been met with in South Africa. At the same time we must note that there are no deposits of rock salt, gypsum, or other soluble substances which characterise formations deposited in an area where evaporation provides the only escape for the water collected in its hollows. Such beds of soluble salts are well known in the red Permian and Triassic rocks of Europe, and they were formed in a desert country in which the rivers flowed into inland basins without an outflow to the sea. Similar beds of salts

are now formed in desert regions. If the Karroo basin had been entirely cut off from the ocean, as Lake Tchad, the Caspian and Aral are now, we should find evidence of it in the deposits laid down at the time.

From the Ecca beds to the Stormberg there are false bedded rocks, ripple markings on the surfaces of numerous strata, both shales and sandstones, and local unconformities caused by the scouring away of the floor by currents which deposited other detritus in the hollow so formed. These all point to the prevalence of shallow water in the Karroo basin throughout the period. When these facts are taken into consideration with the great thickness of the sediments concerned they afford clear proof that a great part of the Colony was slowly depressed during a very long period extending from the Carboniferous to the Jurassic.

The chief rocks of economic value in the Karroo system are the coal seams of the Molteno group, which have been mentioned on a previous page.

Good building stone is obtained from the Beaufort beds near Beaufort West, Fort Beaufort, Graaff Reinet and Queenstown. In general the Beaufort and Ecca sandstones are too dark in colour and too irregular in development to be used otherwise than locally, but the Queenstown stone has a more than local demand owing to its better colour, good working qualities, and a favourable position with regard to railway transport.

In the Stormberg series there are many places where freestone of good colour has been obtained, but the existing quarries are far from the railway.

Many of the public buildings in East Griqualand are built of sandstones from the Molteno beds.

When more quarries have been opened up for the purpose of supplying the up-country villages with stone there will doubtless be many sources of valuable stone discovered; at the present time fair samples of most rocks that might be of great use are practically impossible to obtain.

The calcareous concretions containing clayey matter in the Ecca and Beaufort beds should be of value in cement making, but at present nothing is being done with this limestone. The expense of fuel at places where the limestone is sufficiently abundant to work accounts for its not being used in this way.

Water is almost everywhere found in moderate quantities by boring into the Karroo formation, though the rocks are rarely permeable to any extent. The water obtained comes from the joints which cut through the strata and allow them to hold water within a few hundred feet of the surface. The largest supplies appear to be obtained behind dykes of dolerite, which act as subterranean dams in holding back the water derived from a higher level.

[Since this chapter was written the progress of the survey has made it certain that *Cleithrolepis*, *Semionotus*, and *Ceratodus* come from the uppermost part of the Beaufort series; *Hortalosaurus*, a Dinosaur, occurs in the Cave sandstone, and *Notochampsa*, a crocodile of Jurassic type, has been found in the Red beds and Cave sandstone by Mr. du Toit, who has also obtained phyllocarids and wings of orthopterous insects from shales in the Cave sandstone. Nov., 1904.]

CHAPTER VI.

REPTILES OF THE KARROO FORMATION.

By R. Broom, M.D.

Few groups of fossil reptiles are more worthy of careful study than those found in the Karroo beds of South Africa. The continental conditions which prevailed at the time were favourable to the existence of large numbers and many varieties of land animals, and the lake deposits which were then being formed were well suited for the excellent preservation of their remains. Not only are the fossil reptiles numerous and well preserved but they are forms of the very greatest interest.

The earliest land vertebrates appear to have arisen in Carboniferous times, in rocks of which period we find the remains of a great variety of Labyrinthodonts, but no undoubted remains of reptiles. The Labyrinthodonts were peculiarly specialised Amphibians, characterised among other things by having the head hinged to the back bone by two condyles as in the frog, and not by a single knob as in most reptiles and birds. They survived till the close of the Triassic period, and a number of very interesting forms have been met with in the upper Karroo beds of South Africa.

In the age succeeding the Carboniferous—the Permian—true reptiles first made their appearance, and in the

rocks of North America and Europe have been found the remains of a large number of primitive reptiles, some showing affinities with the existing Tuatara lizard of New Zealand and others resembling more the ancestral Labyrinthodonts.

In South Africa, as we have a continuous series of beds, probably from the Carboniferous to the Upper Triassic period, we have a much better opportunity of studying the succession of the early reptilian types than is met with in any other part of the world. Some of the American and European types are unlike any that have as yet been found in South Africa, but on the whole the best general idea of the early reptiles can be obtained by the study of the South African forms.

Some conception of the extent of the reptilian fauna of the Permian and Triassic beds of South Africa may be gathered from the fact that at present at least fifty-three genera are known and a hundred species. Much difference of opinion has been expressed with regard to the classification of these forms, but as our knowledge has advanced most of the difficulties have been removed, and it is now found that the very large majority of the species can be conveniently arranged in five distinct, though more or less connected, orders. Of these orders the two lower show marked affinities with the Labyrinthodonts, and the highest is surprisingly closely related to the lower mammals. The study of these five orders thus not only gives us a very good idea of the Permian and Triassic reptilian fauna, but enables us to see the steps by which the mammals have been derived from their amphibian ancestors.

PROCOLOPHONIA.

The first order to be considered has been formed for the reception of a single genus, *Procolophon*. At least two well-marked species are known, both lizard-like reptiles about twelve to fifteen inches in length. In general proportions and in many points of structure *Procolophon* bears a marked resemblance to the existing New Zealand lizard, *Sphenodon*; it differs, however, in having a much more primitive condition of back of the skull and of the shoulder girdle and pelvis.

The palate resembles that of *Sphenodon* but differs in having no teeth on the palatines, and in having a large number on the pterygoids and prevomers. The *Procolophon* differs from the large majority of reptiles in having the posterior part of the skull roofed with bone, and in this respect it agrees with the Labyrinthodonts.

The vertebræ are of a very primitive type, retaining the passage for the persistent notochord.

The shoulder girdle has on each side a well-developed scapula, coracoid and precoracoid, supported by a pair of large clavicles and a very large median interclavicle.

The limbs bear considerable resemblance to those of lizards, there being in each foot 2, 3, 4, 5, and 3 joints in the five toes respectively instead of 2, 3, 3, 3, and 3 as in mammals.

Abdominal ribs, such as are found in *Sphenodon*, the crocodiles, and many primitive reptiles, are present.

The pelvis has the anterior elements—the pubes and ischia, broad and flat as in the Labyrinthodonts.

Though no other members of this order are known

either in South Africa or elsewhere there occur in Europe and America one or two genera (*e.g.*, *Sclerosaurus*, *Pariotichus*, etc.), which seem to be intermediate between it and the next order.

PAREIASAURIA.

This order was formed for the reception of a genus of very large fossil reptiles, *Pareiasaurus*, of which in South Africa there are four or five species known. In North Russia a species is known of even larger dimensions than the South African, and in Central Europe a small allied form with horns. In Scotland another small allied form, also horned, has been found; and in America there are numerous genera possibly belonging to this order but not very nearly related to *Pareiasaurus*.

Pareiasaurus was a very heavily built animal about eight or ten feet in length and standing about four feet high. It resembles *Procolophon* in one or two respects, but on the whole is considerably more highly organised.

The skull is very massive, and the surface bones are pitted somewhat after the manner seen in the Labyrinthodonts. In fact even in the arrangement of the bones of the upper surface of the skull the resemblance to the earlier types is very marked. The palate, however, differs entirely from that of the Labyrinthodont and agrees in type with that in *Procolophon* and *Sphenodon*.

The shoulder girdle resembles that of *Procolophon* in having well-developed scapulæ, coracoids and precoracoids, but differs in having a large acromion process for the attachment of the collar bone, and in retaining the

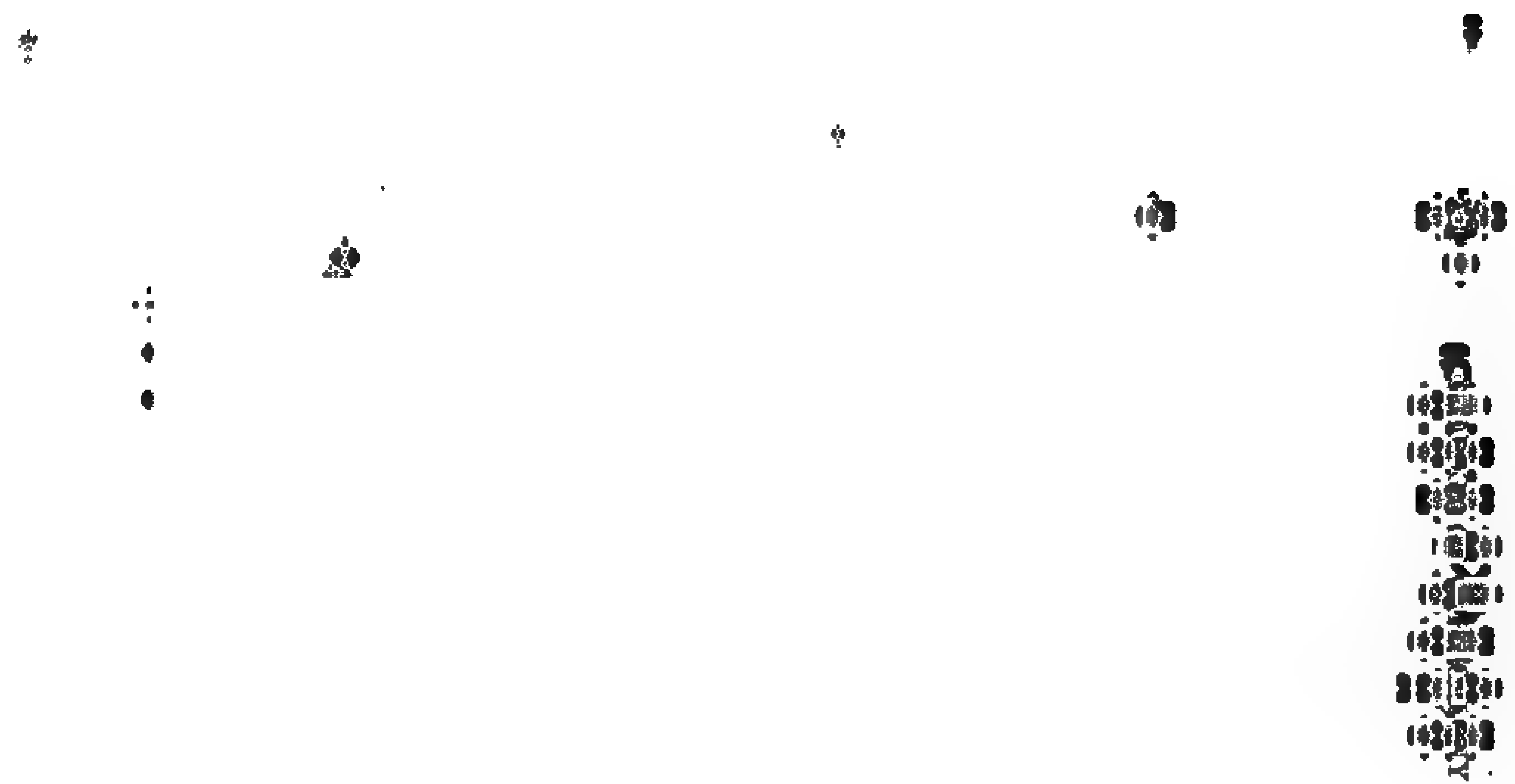


FIG. 18.—Skeleton of *Pareiasaurus serridens* (Owen), restored. The length of the animal was about 8½ feet.

Labyrinthodont supraclavicle or cleithrum — a splint bone which protects the front of the scapula.

The pelvis bears some little resemblance to the mammalian type.

No abdominal ribs have as yet been found in *Pareiasaurus*, and it is highly probable that none existed.

The number of joints in the toes is not yet known for certain. One toe undoubtedly has four joints; possibly the numbers are 2, 3, 3, 4, 3 respectively, thus belonging to a type intermediate between *Procolophon* and the Anomodonts, etc.

THEROCEPHALIA.

Contemporaneously with *Pareiasaurus* there existed a large series of other reptiles somewhat allied but belonging to a different order. Whereas *Pareiasaurus* was a clumsy slow-moving animal, with uniform teeth only suited for cropping herbage, the other types are for the most part slightly built animals and having teeth differentiated, as in mammals, into incisors, canines and molars. Considerable confusion has hitherto been caused by these early carnivorous types having been placed with the Theriodonts to which they are not very nearly related.

The skull bears considerable resemblance to that of mammals, differing mainly in the structure of the palate and of the lower jaw and its hinge. Each premaxillary bone usually carries five pointed incisors, and in the maxillary there are usually two canines, sometimes three, and a series of small pointed molars. The molars vary in number from one to eleven. The palate is a

slight modification of that found in *Procolophon* and *Pareiasaurus*, the internal nasal opening being by the side of the canines, and there is no trace of a secondary palate. On the pterygoid bones there are usually a series of small teeth.

Of the lower jaw the dentary bone only forms a little more than the anterior half, the posterior part being formed by three other large elements as in most reptiles. A well-developed quadrate bone is present for the articulation of the jaw. There is a single occipital condyle.

The limb bones differ from those of *Pareiasaurus* mainly in being long and slender. There is in the shoulder girdle no acromion process.

The best known South African Therocephalians are *Ælurosaurus*, *Ictidosuchus*, *Lycosuchus* and *Titanosuchus* animals varying in size from a cat to a horse. A very much larger form, *Tapinocephalus*, is met with. It was an animal probably as large as a rhinoceros, but it is unfortunately very imperfectly known and possibly belongs to the *Pareiasauria*.

In Russia a number of Therocephalians have been found, the best known being *Deuterosaurus* and *Rhopalodon*. Recently very perfect skeletons of a large form, Nostronzewia, have been found in North Russia.

Anomodontia (or Dicynodontia).

The Anomodontia include a large series of fossil forms, characterised among other things by having, like the Edentata among mammals, no teeth in the

front of the jaw. In general structure they are intermediate between the Therocephalians and the Theriodonts, but they also show some affinities with the Pareiasaurians. In size they vary from animals as small as a rat to huge heavily built forms somewhat larger than a wild boar.

The skull resembles considerably that of the Therocephalians and the Theriodonts, and is mainly remarkable for the enormous development of the squamosal bone and the large size of the quadrate. The palate resembles much more closely that of the Theriodonts than the type met with in the earlier forms.

The shoulder girdle resembles very closely that of *Pareiasaurus*, there being usually present a distinct cleithrum. An ossified sternum or breast bone is probably invariably present.

The bones of the fore limb also resemble those of *Pareiasaurus*, the humerus having always a huge deltoid ridge. The front foot very closely resembles that of mammals, the toes having 2, 3, 3, 3, 3 joints respectively.

The pelvis and the bones of the hind limb are strikingly mammal-like.

The best known Anomodont genus is *Dicynodon*, of which over twenty species have been discovered, some smaller than a cat, others possibly nearly as large as *Pareiasaurus*. The jaws in front formed a horny beak as in the tortoise, but in addition there were two powerful tusks, between which the lower jaw worked. There were no other teeth. In the larger species the head is usually proportionally very large. In *Dicynodon leoniceps*

the head is narrow; in *Dicynodon tigriceps* it is very broad.

Oudenodon is closely allied to *Dicynodon*, but differs in having no tusks. A considerable number of species are known varying from less than a foot to probably about six feet in length.

Lystrosaurus (= *Ptychognathus*) is an aquatic form of Anomodont. The limbs are very short and ill-adapted for progression on land. The head, though agreeing fairly closely with *Dicynodon* as regards its essential structure, is remarkably distorted. The beak is long and the back part of the head very short, while the occiput and snout lie in almost parallel planes. The eye and the nose are close together and near the top of the head. The peculiar shape of the skull would enable *Lystrosaurus* to lie near the surface of the water with only the eye and nose exposed.

Endothiodon may be taken as the type of a number of genera, closely allied to *Dicynodon* and *Oudenodon*, but differing in having a number of teeth on the maxillary bone and in the lower jaw. Some of the genera are less than a foot in length and have remarkably specialised teeth, while *Endothiodon bathystoma*, the largest form known, was between three and four feet in length. In this large form the maxillary and lower jaw teeth are arranged in three series. The head is of enormous size, with a large parietal crest and a very wide occiput. The vertebræ are short, the ribs well developed and the limb bones very similar to those of *Dicynodon*. The Endothiodonts form a connecting link between the Therocephalians and the Anomodonts, such as *Dicynodon*

[illegible] restored.

This is one of the smaller known species of *Oudenodon*. The larger species are somewhat more heavily built. In the restoration the tail is partly hypothetical. No specimen of any species of *Oudenodon* is known in which the tail is preserved, but one species of *Dicynodon* is known to have a short slender tail. The length of the animal was about 14 inches.

and *Oudenodon*, but they are very much more nearly related to the latter.

THERIODONTIA.

The Theriodonts are medium-sized reptiles remarkable for the strikingly close resemblances which they bear to mammals. Only a few genera are known at present, but fortunately most of the important points of structure have been revealed. The best known genera are *Cynognathus*, *Gomphognathus*, *Microgomphodon* and *Galesaurus*. The Theriodonts are the carnivora of the upper Karroo rocks as the Therocephalians are of the lower.

The Theriodont skull resembles considerably that of both the Anomodonts and the Therocephalians, and also bears a close affinity to that of the lower mammals. The most remarkable features of the skull are the presence of two occipital condyles and the development of a secondary palate. The lower jaw is formed almost entirely by the dentary bone, the other bones being of small size. The quadrate is quite rudimentary. The dentition is almost typically mammalian, and not only are the teeth divided into incisors, canines and molars, but the molars are specialised in different genera into carnivorous and insectivorous types. The palate is formed as in mammals by secondary plates from the maxillary and palatine bones, the internal nares being carried as far back as in most mammals. The pterygoid bones are of large size as in the Anomodonts and Therocephalians and unlike those of mammals.

The vertebræ are remarkable for having peculiar flat overlapping ribs in the lumbar region.

In the shoulder girdle the scapula, coracoid and pre-coracoid resemble much more those elements in the Anomodonts than in the Therocephalians.

The pelvis is much more mammalian in type than that of the earlier forms.

Cynognathus, the best known genus, is a large wolf-like reptile. The head is about sixteen inches in length and the whole animal probably measured about six feet. The molar teeth have cusps very similar to those seen in many carnivorous mammals.

Gomphognathus, though very similar to *Cynognathus* in general structure, differs in having a broad and flat head and in having the molar teeth with flattened crowns. It probably measures about four feet.

Microgomphodon is a small form with flattened molars. It is about the size of a meerkat.

Galesaurus is a small carnivorous type, of which only the skull is known. The head is more depressed than in *Cynognathus*.

Relations of the Theriodonts to Mammals.

The study of the fossil reptiles of South Africa has not only revealed some very remarkable types of animal life, but has practically resulted in the solution of one of the most vexed problems of biology—the Origin of Mammals.

In *Procolophon* we have a type which, though distinctly more closely allied to the ancestors of the lizards, is

probably not very unlike that which formed the common ancestor of the *Pareiasaurians*, the mammal-like reptiles and the mammals.

Pareiasaurus, though possibly in one or two respects more primitive than *Procolophon*, is on the whole distinctly specialised along the line which gives rise to the mammals. The shoulder-girdle and pelvis are strikingly like those of the lower mammals. The well-developed acromion process which forms so marked a feature of the shoulder-blade of mammals appears in *Pareiasaurus* for the first time.

The Therocephalians in some respects resemble mammals fairly closely. The general arrangement of the face bones and those of the upper surface of the skull generally is surprisingly mammal-like, and the teeth are divided into incisors, canines and molars almost exactly as in the higher forms.

The Anomodonts though somewhat out of the direct line of mammalian descent, are even more nearly related to the mammals than are the Therocephalians. We here see the secondary palate in its early imperfect condition. Most of the bones of the skeleton are so like those of the Monotremes that Owen many years ago suggested the possibility of the ancestors of the Monotremes being found among the Anomodonts.

The Theriodonts are most probably descended from Therocephalian ancestors, but they have so far advanced along the mammalian line that they are more closely allied to their mammalian descendants than to the Therocephalians. In the structure of their teeth, palate and limb bones they may be said to be almost mammals.

[illegible] *derrieti* ; length [illegible] *athus platyceps* ; [illegible] *Dasyurus macu-* [illegible]

[illegible] tal ; Ju., Jugal ; [illegible] nx., Pre-maxilla ; [illegible] ng., Surangular :

[illegible] n the Theriodonts, [illegible] mals of Australia [illegible] sses very similar to

To whatever point in the structure of the Theriodonts we turn we find the mammalian condition foreshadowed in a most remarkable manner. The two points in which the mammalian skull differs most markedly from the reptilian are (1) the simple nature of the lower jaw, and (2) the presence of two occipital condyles. Both of these peculiarities are explained by the Theriodont condition. The Theriodont jaw differs from that of the Therocephalian and all other reptiles in being formed almost entirely by the dentary, which almost reaches the articulation. The articular is small and to a great extent overlapped by the dentary. The angular, surangular and splenial are small rudimentary splint bones. The quadrate on which the articular hinges is a small bone which lies on the front of the downward process of the squamosal. In the mammal the lower jaw is formed entirely by the dentary; and the quadrate has disappeared as a distinct ossified element, so that the dentary hinges on the squamosal. It will thus be seen that the mammal differs from the Theriodont only in its having lost those elements which already are rudimentary in the Theriodont. The quadrate appears to be completely lost in many mammals, *e.g.*, Monotremes, but it is probably represented by the interarticular cartilage in the large majority of forms. The articular element of the jaw is possibly represented by the cartilage found in the condyle during development; and a small splint bone in the jaw of the very young Ornithorhynchus probably represents the angular.

The occipital condyle in the Theriodont is merely a modification of that found in the Anomodonts. In those

a large single condyle occurs formed by the two exoccipitals and the median basioccipital. In the Theriodonts the basioccipital takes less part in the formation of the condyle than the two lateral elements, and hence the condyle appears to be double. In some of the lower mammals a condyle essentially similar in structure occurs, the basioccipital forming part of the joint, but in most of the higher forms the basioccipital takes little or no part, and thus what was originally a single condyle formed by three elements becomes a double condyle formed by the two lateral elements alone.

Though the above view of the origin of mammals seems to have on its side the very strongest palæontological evidence, various other theories have been proposed. Many would derive the mammals directly from Batrachian ancestors through a long line, of which we know nothing, originating in Devonian times. The quadrate bone of the Batrachians and Reptiles they consider becomes one of the auditory ossicles in the mammal. By others the mammalian tympanic bone is regarded as the homologue of the reptilian quadrate. Neither of these views has the slightest support from palæontology.

Other Reptilian Types.

While the large majority of South African fossil reptiles belong to the phylum which terminates in the mammals there are a few other interesting forms.

A small lizard-like form called *Saurosternon* is believed to be allied to the New Zealand lizard, *Sphenodon*, but

it may be a true lizard. Another form known only by the skull, *Paliguana*, has the quadrate bone free and must thus be classed with the Lacertilia.

Proterosuchus is a moderate-sized reptile with a long narrow pointed skull. Though having affinities with *Sphenodon*, it also shows a number of resemblances to the Primitive Crocodiles and Dinosaurs, and it would seem to belong to a group which included the common ancestors of Crocodiles, Dinosaurs, Pterosaurs and Birds.

A few Dinosaurs are known, which resemble fairly closely the Triassic Dinosaurs of Europe and America.

[Since the above was written evidence has been obtained which renders it probable that *Saurosternon* belongs to the Procolophonia.

The most important recent discovery among the Karroo Reptiles has been that of small crocodiles in the upper Stormberg beds. They belong to a genus which has been named *Notochampsa*. Though only about two feet in length they are fairly closely allied to certain crocodiles found in the lower Jurassic beds of Europe. Unlike modern crocodiles they have fairly long legs, and were no doubt able to run swiftly.]

CHAPTER VII.

THE INTRUSIVE DOLERITES AND ALLIED ROCKS.

THE dark-coloured, heavy rock, blue-black when freshly broken, and red-brown, black or yellow on weathered surfaces, that occupies such great tracts of country north of a line drawn between Sutherland and East London is generally known by the name of ironstone, or yzer-klip to the people who live near it. It probably got the name from the property it has of ringing like a piece of metal when struck. This rock is composed chiefly of four minerals, plagioclase felspar, augite, olivine and magnetite, in the order of their relative abundance and commencing with the most abundant mineral. There are other constituents, some of which can be found in every piece of the rock examined; but they are of less importance than those just mentioned, and will be spoken of later.

The mineral composition shows that the rock belongs to the basic group of igneous rocks, and the few chemical analyses that have been made of it show that it has a similar composition to that of dolerites known from other countries. In this book, as in the Reports of the Geological Commission, the name dolerite is used in the

sense adopted by Allport,[1] and Teall,[2] including rocks composed chiefly of plagioclase and augite. They may or may not contain some glass between the usual constituents. The composition varies considerably throughout the country, but in very many localities rocks with obviously different compositions can be seen to belong to one and the same mass. The chief change in composition is in the amount of silica, which has the effect of altering the proportion of some of the minerals present; as a general rule the more silica there is the less olivine and augite is seen in the specimen. If strict attention be paid to the mineral and chemical composition of the rocks, those belonging to the great group we are now describing must be given several names. Few of these can be determined without a minute examination of the specimens. The intrusions as a whole can conveniently be called dolerites.

According to the shape of an intrusive mass of igneous rock and its relationship to the surrounding rock it is called a dyke, sheet or sill, laccolite, or a boss or batholite.

Dykes are masses of rock filling vertical, or steeply inclined fissures. They may traverse sedimentary or

[1] *Q. J. G. S.*, xxx., p. 529.

[2] *British Petrography*, ch. vii. These rocks generally correspond to the diabase of Rosenbusch and Zirkel, although many examples would belong to the basalt and dolerite of these authors if the question of geological age were left out of account. It may be well to mention for the benefit of those who have no acquaintance with petrography that the naming of igneous rocks is still in a state of confusion or something very like it, and that very many names should not be used without reference to the author whose usage is followed.

igneous rocks. The width of a dyke does not as a rule vary greatly, so that when the dyke-rock is more resistant than the enclosing beds it has the appearance of a wall. Dolerite dykes are abundant in the Colony, an example of these being shown in Fig. 11.

A sheet or sill is a similar body to a dyke, but it lies approximately parallel to the bedding planes of the sedimentary rocks it penetrates. Sheets of dolerite are more abundant in the Colony than any other form of intrusion; they are shown in Figs. 1, 2 and 4, and Plates XIII. and XIV.; they are often connected with dykes that in some cases may be regarded as the channels through which the rock composing the sheets flowed.

A laccolite is of the nature of a sheet that is very thick in proportion to its extent and thins out on every side, forming a thick lenticular mass. A laccolite, moreover, often raises the overlying sedimentary beds into a dome corresponding to its own contour. Certain of the large masses of dolerite in the east of the Colony are perhaps laccolites, but the arching up of the overlying beds has not been observed.

A boss or batholite is a large deep-seated mass of more or less irregular form and of unknown depth, but no examples of this type of intrusion are found amongst our dolerites. Several of the granite masses in the Pre-Cape rocks belong to this type of intrusion.

It will have been noticed that no mention has been made of lava in connection with the dolerite. The masses here described all consolidated at some distance below the surface of the earth, and can be seen only by the removal of the overlying rocks by denudation. A

Plate XIII.—A dolerite sheet at Paalhuis under the Nieuweveld escarpment. The dolerite is the dark rock at the top of the cliff; it cuts through the lighter coloured sandstones and shales (Beaufort beds) at an angle to the bedding.

PLATE XIV.—The falls of the Tsitsa River in East Griqualand. The river falls about 370 feet over a dolerite sill some 250 feet thick, the lower part of the cliff is made of hardened shale and sandstone.

lava is an igneous rock which has flowed from a vent or a fissure over the surface, and though of very varying nature it may have the same chemical and mineral composition as dolerite. Ancient lava flows that have been deeply buried under sedimentary rocks and are now exposed at the surface by denudation have some characters in common with sheets or sills ; in the case of very ancient sheets of igneous rock lying parallel to the bedding of slates or other sedimentary rocks, it is often very difficult or even impossible to decide whether the rock was a lava flow or an intrusive sheet. With rocks that have not undergone much alteration since their formation there is not this difficulty, for lavas are usually rough and slaggy at both their upper and lower surfaces, and the sediment deposited upon them is not hardened at the contact as are the beds above an intrusive sheet. The only serious difficulty in distinguishing between lavas and sills of slightly altered rocks is met with in the case of sills intruded amongst lavas of similar composition. Examples of this are to be found in the volcanic group of the Stormberg series, and there is some doubt as to their true nature. Amongst the hundreds of dolerite sheets that have been examined in the rocks, older than the Stormberg volcanic group, none has been found to have the characters of a lava flow, but there is often conclusive evidence in the hardening of the overlying rock and in the sheet breaking through to a slightly higher or lower horizon that the rock is intrusive, *i.e.*, that it was injected into its present position in a molten state after the surrounding sedimentary rocks were deposited.

It was stated in the Introduction that the dolerite intrusions are practically limited to that part of the Colony which was not seriously affected by the earth movements that took place subsequently to the deposition of the Ecca beds. In the west of the Ceres Karroo a nearly straight dyke about thirteen miles long and 100 feet wide runs north and south through Beukes Fontein, traversing the Dwyka conglomerate where that rock dips somewhat steeply to the east. This dyke dies out at each end and gives off no sheets. In the valley of the Brandewyn's River there are two dykes traversing the Bokkeveld and Table Mountain series in an area where these beds are slightly folded, and in the neighbourhood of Groen River and the Bokkeveld Mountain escarpment there are also two dykes breaking through beds belonging to the Cape formation, but the beds have there been only very slightly disturbed. No dolerite intrusions have been met with in the great folded belt between the Clanwilliam Mountains and the Gualana River. We have to go to Pondoland[1], where the Table Mountain sandstone lies almost horizontally before we again come across dolerite in the Cape formation; it occurs there as a dyke in the sandstone of the Egossa forest.

A considerable number of dolerite dykes penetrate the Ibiquas series in the west of Calvinia, but it is in the rocks belonging to the Karroo formation that the intrusions attain their greatest development.

[1] Since this was written Mr. du Toit of the Geological Survey has found two dolerite dykes penetrating the Table Mountain sandstone of the Cape Peninsula, which lies outside the folded belt.

In the Tanqua Valley east of Eland's Vley there are several dykes with a north-westerly trend, and some of them are connected with small sheets, but the main area of the dolerite intrusions commences on the north of the Tanqua.

In the Dwyka series between the Langebergen (Calvinia) and the Tanqua Valley there is a very extensive sheet which stretches with a few breaks in the northern part of the outcrop for rather over 100 miles, and it is at places 300 feet thick. This sheet and indeed all those in the western part of the country tend to rise towards the south-east, and they traverse higher and higher beds in the same direction. The lowest sheet first appears near the base of the Dwyka conglomerate north of the Oorlog's Kloof River, but at the south-east extremity on Potkly's Berg East it is in the lower part of the Ecca beds, having passed diagonally through a thickness of about 1,000 feet in the course of some sixty miles. In looking at such a sheet at any one part of its outcrop it appears to have been injected parallel to the bedding planes of the enclosing rock, and it is only by the examination of a very long outcrop that the fact of its breaking across the bedding can be determined; clearly cut sections are difficult to obtain except on vertical cliffs, and these are not abundant in the case of this sheet. The sheet is crossed by the main road from Ceres to Calvinia at Bosch Kloof, where it forms an outcrop about six miles wide. It forms a considerable part of the upper slopes of the escarpment called Eland's Berg; the hill is capped by the Upper shales of the Dwyka series which in turn are overlain

by a smaller sheet of dolerite, an outlier of an offshoot from the lower one. Outliers of the lowest sheet cap the Guap Mountain and Klip Rug Kop; the latter is a very conspicuous conical mountain formed of Dwyka conglomerate standing on the watershed between the Wolf and Oorlog's Kloof Rivers. The offshoot from the lowest sheet in Calvinia is probably connected with the latter near the Drie Fontein Mountain, but the outcrops are apparently separated; it runs along the foot of the Roggeveld escarpment as far as the Rhenoster River, a distance of fifty miles; but near its point of departure from the lowest sheet there is a second offshoot at a higher level traceable for over fifty miles on the escarpment as far as Sneeuw Krantz (Boven Plaats) on the Roggeveld. A fourth sheet is connected with the third at Roode Fontein on the edge of the Roggeveld, and in addition to forming the edge of the escarpment for many miles south of Roode Fontein, it covers a wide extent of country to the north round Kreits Berg (Zand Kop), Roep-my-niet, and Hantam, in addition to a great tract to the east. The Roggeveld sheets below the fourth or highest one in this area do not extend into the Sutherland and Beaufort divisions. It is not certain as yet whether the fourth sheet, the one that crowns the Roggeveld at Roode Fontein, is connected on the surface with those north-east of Sutherland. The latter are the continuation of a sheet that forms the summit of the western Nieuweveld, whence it gradually drops to the level of the northern part of the Gouph. This great sheet, traced between points 100 miles apart, is connected at the eastern end, where it is cut through

by the Koekemoer's River, with a steeply inclined sheet or dyke at a lower horizon, which has itself been found to extend over sixty miles to the west with a continuous outcrop. This inclined sill, which is called the Roode Hoogte sheet, dips at about 30° to the north, and is as much as 400 feet thick in places. Like the overlying sill, the Roode Hoogte sheet rises towards the Roggeveld; it makes a rapid ascent west of Banks Gaten on the extreme western limit of the Beaufort West Division. The dolerite krantz runs up the left bank of the head-waters of the Dwyka River, which for the first six miles of its course has a most remarkable cañon-like valley. A tributary has cut off a big out-lying portion of the sheet in Alleman's Hoek, and to the west of that locality the dolerite strikes across the plateau behind Komsberg, passes a few miles to the north of Saltpetre Kop and disappears near Jackal's Fontein on the Sutherland main road.

East of Tafel Berg, that fine flat-topped mountain with such gracefully shaped slopes below the krantz (400 feet) of columnar dolerite, and which can be seen, together with its neighbour, Spitzkop, from the railway beyond Prince Albert Road, the Nieuweveld summits are formed by outliers of sheets that occupy wide stretches of country behind the escarpment. Some of these sheets appear as continuous outcrops, usually in the form of krantzes or cliffs from 100 to 400 feet high for about twenty miles along the edge of the escarpment, the highest point of which is the peak called Bulthouder's Bank, 6,270 feet above the sea and

3,500 above the town of Beaufort West that lies about seven miles to the south-east.[1]

From one of the prominent peaks near the edge of the escarpment, such as the Tafel Berg just mentioned, or Javander Kop near Steenkamp's Poort, a magnificent view lies before one. To the north range upon range of rough dolerite kopjes, occasionally merging into more important hills, stand upon the plateau that ends abruptly in the Nieuweveld escarpment; almost at one's feet is the edge of the escarpment, with a dolerite krantz at the top, and often one or more on the precipitous slope of some 3,000 feet from the summit to the level of the Karroo at the bottom; to the south stretches the Great Karroo with its low ranges of flat-topped kopjes of shale and thin sandstones, shut in on the horizon by the blue slopes and peaks of the Zwartebergen. The dolerite outcrops do not extend farther than eighteen miles south of the Nieuweveld escarpment, rarely so far.

The Roode Hoogte sheet, which is inclined northwards at a moderate angle, fronts the Great Karroo for nearly fifty miles, and forms the southernmost of the dolerites for a distance of over seventy miles. It may have extended some way farther south than its present outcrops, but as there are no other dykes to the south, that is, no channel whence further sheets could have been supplied, and as there are no outliers of dolerite in that direction,

[1] A detailed description and map of the sheets and dykes of the eastern Nieuweveld will be found in *Geol. Comm.* (96), pp. 15-26; of the Roggeveld in *Geol. Comm.* (00), pp. 50-52 and (03). A map accompanies the latter Report and that of 1896.

we must regard the present outcrop of the Roode Hoogte sheet as near the former southern limit of the intrusions.

In the area between the town of Beaufort West and the west end of the Nieuweveld escarpment there are several thick dykes with a northerly inclination; one of them runs through the town, and behind it the two town dams have been made by blocking up the exit of streams; this, the Beaufort dyke, has been traced over more than thirty miles and gives rise to a thick sheet at Stoltz Hoek. On the road to Fraserburg up Thee Kloof there is a thick dyke very well exposed for hundreds of feet on the steep sides of the valley; two thin dykes lie parallel to it. The exact position of the dykes and sheets of the southern edge of the dolerite country is not known east of Beaufort West, but they run between Aberdeen and Graaff Reinet, thence through the country just south of Bedford and Fort Beaufort to a point south-west of East London where they disappear under the sea. North-east of East London they appear in great force in the Komgha Division and throughout the whole of the Transkei, Pondoland and Griqualand East, and they are continued right through Natal.

The position of the southern limit of the dolerite intrusions is shown approximately in the small map in Fig. 3. North of this line the dolerites are very widely spread. In the western part of the country, in the drainage basin of the Zak, Hartog's Kloof and Onger's Rivers the dolerite forms the innumerable kopjes and ridges mentioned in the description of the

view from one of the Nieuweveld peaks. The most important ranges of dolerite hills in this part of the country are the Karree Bergen, Slang Bergen, Tulbagh Mountains, Kat Kop hills and the hills south of Williston (Amandelboom). Farther to the east, from the Fraserburg boundary to the Stormberg, the conical mountains with flat tops of dolerite or with pinnacles, remnants of former table-shaped summits, are very frequently met with.

There are some very considerable ranges of mountains that run more or less parallel to the main watershed in the Eastern Province and divide the country south of that watershed into two parts, a northern (Middelburg, Cradock, Tarka, Queenstown), drained by the main branch of the Great Fish River and the Kei; and a southern (Graaff Reinet, Somerset East, Bedford, King William's Town, etc.), drained by the Sunday's River, tributaries of the Great Fish and Kei, Keiskamma and Buffalo Rivers. These mountains branch from the main watershed at the Compass Berg (8,500 feet), which is the highest point in the Colony, except some of the peaks of the East Griqualand boundary; they are called the Sneeuwbergen, Tandjes Berg, Bank Berg, Winterbergen and Amatolas in different parts of their course. They all appear to owe their existence to the presence of thick sheets of dolerite that have protected the sedimentary rocks from destruction. The distribution of these sheets and their relations as parts of a great system of intrusions have not been worked out, but there can be no doubt that they connect the well-known intrusions of Beaufort West and Calvinia

with those of Kentani[1] and the Native Territories generally.

To the east of King William's Town in the country within forty or fifty miles of the coast the dolerites have much less effect upon the topography of the land than in the western districts, or rather it would be more correct to say that the effects are less obvious, for we no longer find the outcrops marked by krantzes or definite ranges of kopjes. The reason of this is that the country is covered with grass or bush, and the soil accumulates on the slopes as well as on the flat ground instead of being rapidly removed from the slopes to lower levels by rain, as is the case in the Karroo, the high country north of the main watershed, and in the higher parts of Griqualand East.

There is perhaps more rapid variation in thickness in the Kentani sheets than in those of the Nieuweveld and Roggeveld. The Kentani Division is the only compact tract of country consisting largely of dolerite that has been mapped geologically in the east of the Colony, and a short description of it, illustrated by the accompanying plan (Fig. 21), will serve as a typical example of the manner in which the intrusions occur in those parts. The district is bounded by the Gcua and Kei Rivers on the south-west, the Kogha on the north-east, the shore on the south-east, and the main road to Umtata on the north-west.

The sedimentary rocks are shales and sandstones containing *Oudenodon* and belonging to the Beaufort series.

[1] A large scale map of the Kentani intrusions has been published in *Geol. Comm.* (01).

They dip at very low angles to the north-west, and are not folded to an appreciable extent.

The lowest sills are found on the coast where there are two called the Kobonqaba and the Mazeppa Bay sheets respectively from the localities where they are

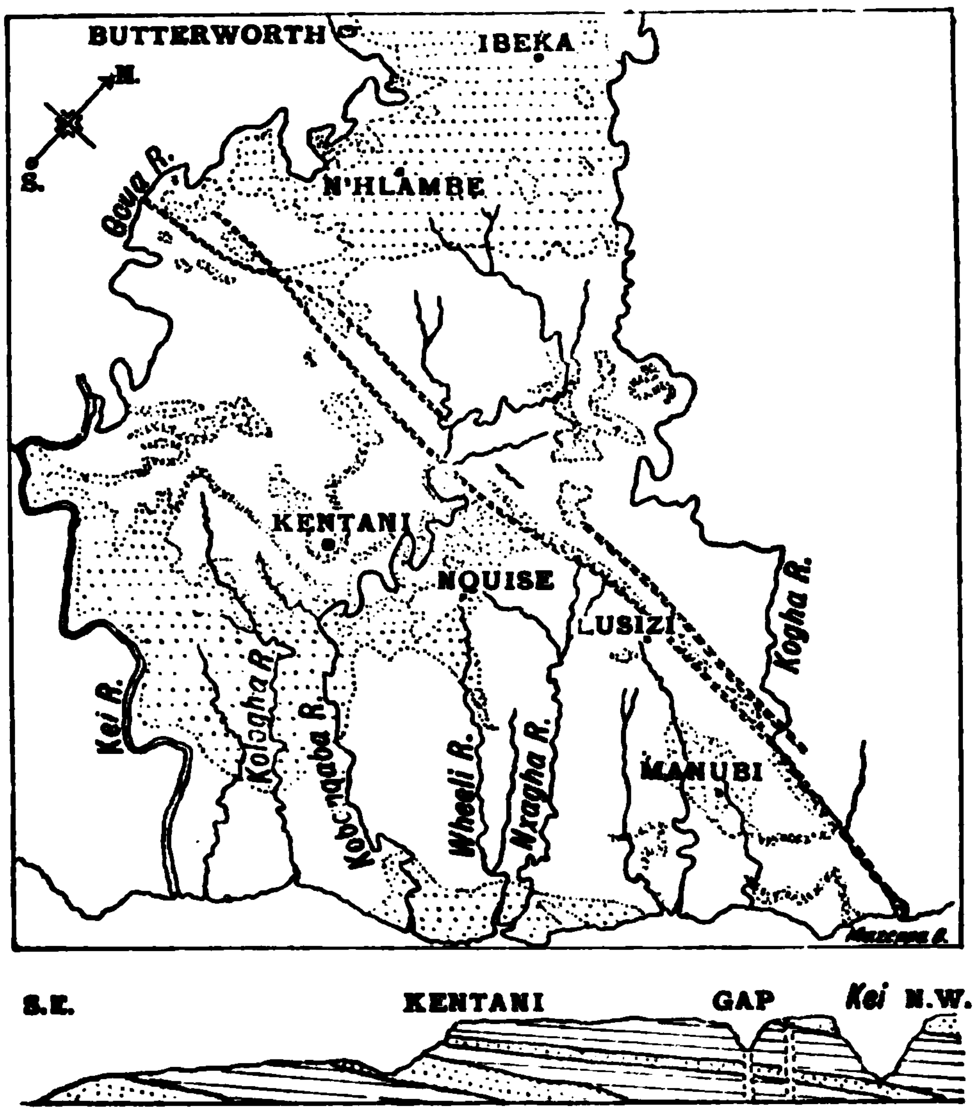


FIG. 2.—Map of Kentani showing the distribution of dolerite sheets and "gap" dykes. The area left blank between the Kei and Kogha rivers is made of sandstones and shales of the Karroo formation. Scale 1 in. to 10·6 miles. The vertical scale of the section is much exaggerated, $\frac{1}{8}$ in. to 1,000 feet. The name Manubi is written across the Manubi sheet. The trading station of that name is to the east.

well exposed. The Kobonqaba sheet extends nine miles along the coast and about two and a half miles inland at its broadest part up the Kobonqaba Valley, where it disappears underground. Its greatest observable thickness is 300 feet, near the Wheeli River, but the bottom is nowhere seen. The patch of sedimentary rock on the

coast, north-east of the Nxagha River, is part of the overlying beds faulted down on the north side against the dolerite. An interesting feature in this sill is the occurrence of dykes of a much more siliceous type of rock than the dolerite they traverse. On Plate XV. is shown a thin dyke of light colour traversing the sheet on the shore near the Kobonqaba mouth. The sheet itself is a rather coarse-grained olivine-dolerite, with well-developed ophitic structure, that is, the augite occurs in rather large, irregularly shaped masses into which well-formed crystals of plagioclase felspar project, or they may be entirely enclosed by the augite; a small quantity of green hornblende is intergrown with the augite and red biotite, magnetite and apatite are present in fair quantities; the olivine is partly converted into serpentine. A very small amount of quartz is also present. This rock is very like that forming many of the Transkei and Pondoland sills, and contains more hornblende than is usually seen in the dolerites of the western districts, although the same mineral is not entirely absent in the latter. The light-coloured dyke has no olivine or augite in it and very little hornblende, which is at places intergrown with orthoclase felspar; red mica is abundant; the plagioclase forms zoned crystals, *i.e.*, crystals whose composition changes regularly from the kernel to the outside, thus having corresponding changes in the optical character of the succeeding layers in each crystal that are easily detected under the microscope. In addition to the plagioclase felspar there is much orthoclase in the rock, intergrown with quartz to form micropegmatite. Orthoclase is practically absent from the olivine-dolerites,

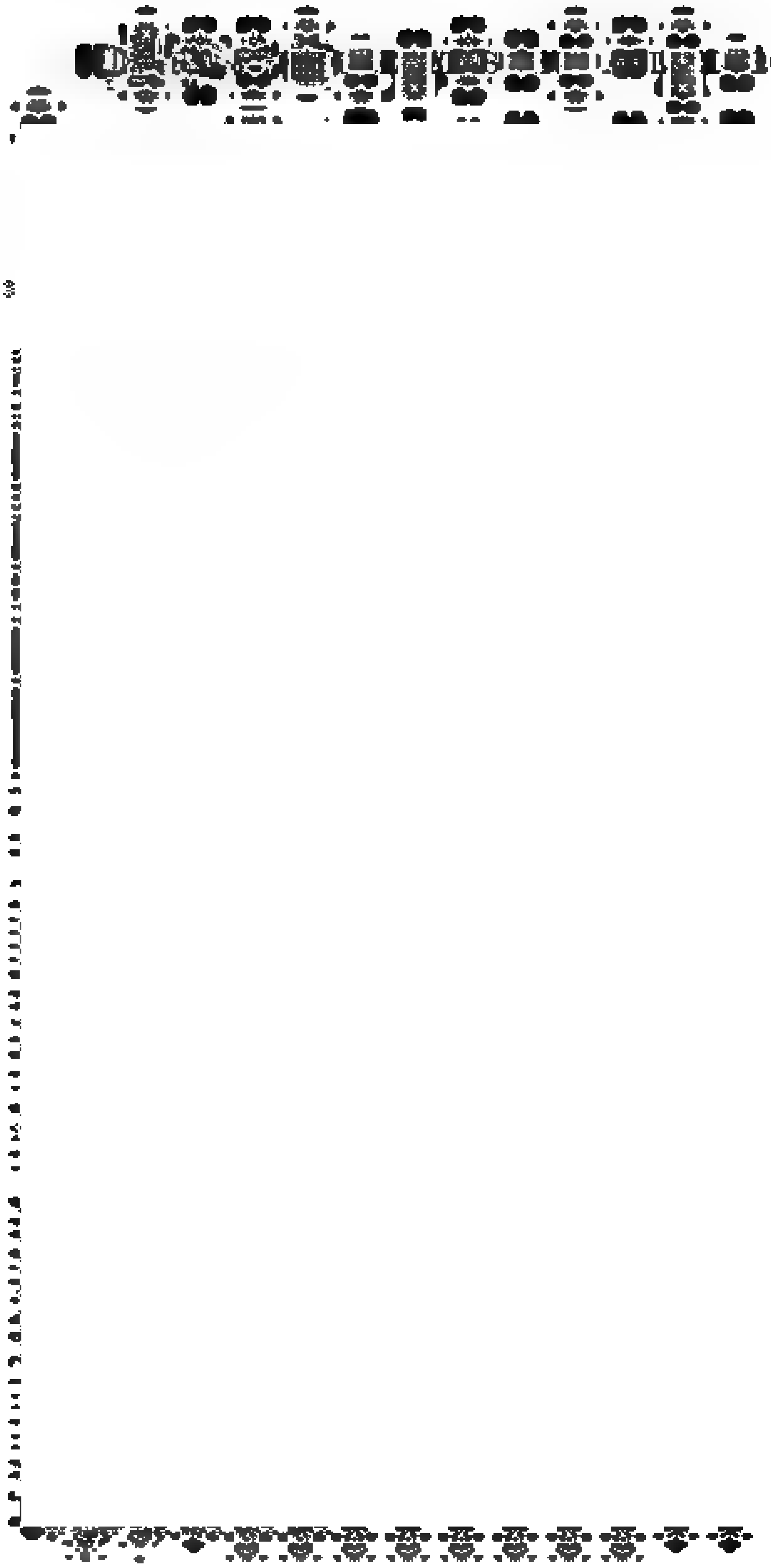


PLATE XV.—Dyke of granophyre (light-coloured) traversing a thick sheet of dolerite near mouth of Kobonqaba River, Kentani.

and quartz is of very rare occurrence. Apatite, magnetite and zircon are found in the acid rocks, as well as in the dolerites.

A rock similar to the acid dyke near the Kobonqaba mouth is seen a little farther to the north-east in the same sheet, and on the left bank of the Nxagha River, about one and a half miles from its mouth, there is a large dyke of the same nature, but with large plates of titaniferous magnetite, which appear as long needles in a cross-section.

Although these acid rocks, which may be called granophyres (Rosenbusch) on account of the abundance of micropegmatitic intergrowths of quartz and orthoclase, are so different from the typical olivine-dolerites, there is strong reason to believe that they were the latest intrusions from the same source that produced the dolerites at a slightly earlier period. Many of the minerals in the acid rock are identical with those in the dolerites, in fact there are no minerals peculiar to the former, it is chiefly the large proportion of quartz and potash felspar and a corresponding decrease in the augite and lime-soda felspars in the granophyre that distinguish it from the basic rock.

The Mazeppa Bay sheet is exposed along a mile of the coast and has been followed as a thin sheet round the basin of the Kleena River and across the Manubi River, about four miles round the lower part of the Manubi Forest. The Mazeppa Bay sheet may be connected with some irregular outcrops of dolerite on the shore between the Manubi and Kleena Rivers. The upper surface of one of these masses of dolerite is seen

to cut off a bed of sandstone obliquely through a vertical thickness of about 4 feet, and then to pass beneath the succeeding bed. There are several large dykes striking inland from the coast between the Kogha and Kobonqaba Rivers, probably connected with one of the inland sheets.

A thin sheet winds round the divide between the Istamfoona and Umfane Rivers, perhaps an outlying portion of the Kobonqaba sheet.

The Manubi sheet crops out on the right bank of the Kogha, at the junction of the Kabakazi stream, where it is 500 feet thick; it thins out rapidly to the west, and is represented by thin outliers north and south of the Kabakazi Valley. Near the Manubi trading station the outcrop turns south-west along the top of the escarpment on which the forest is situated, and extends some seven miles to a point beyond the Gqunqi station; north of Gqunqi it is cut into by the stream to a depth of 300 feet, yet the lower surface is not exposed; it thins out in this direction very rapidly and disappears.

Near Gqunqi there is a short dyke-like mass of granophyric rock, rather like the acid dykes in the Kobonqaba sheet; it traverses both the sedimentary rocks and the Manubi sheet; the granophyre dyke is a mile long from north to south and several hundred yards wide.

The upper half of the Kologha Valley lies in an extensive sheet, of which only a part is exposed in the Kentani Division, for it is continued across the Kei in the Komgha Division. The main part of the sheet extends eastwards from the Kei below the junction of the Gcua. The cliffs and slopes on the left bank of the

Kei for a distance of four miles rise some 1,200 feet above the river, and two-thirds of the vertical height are composed of the dolerite of the Kologha sheet. On Inver Gcua the sheet dips northwards across the sedimentary rocks; eastwards from this neighbourhood it gives off two thin sheets whose outcrops wind round the north side of the Inver Gcua ridge, and the lower one is continued round the Kombolo and Umnyama Rivers. Another off-shoot leaves the main sheet at Riverstone, and winds round the Kentani escarpment to join the main sheet again south of Kentani; east of this point the upper sheet separates again and pursues an independent course as far as the bend of the Kobonqaba River at the Columba Mission Station, where it again joins the lower part of the sheet. The lower or main portion of the sheet forms an area of some twenty-five square miles between the Kei and Kologha, and is continued to the north as far as Cat's Pass, where it is cut through by the southern of the gap-dykes which will be mentioned presently. The outcrop has a complicated form owing to the outliers of the overlying shales and sandstones at Nquise, Nxaxo and other places, and the large inliers of the same rocks under the Kentani escarpment. The thickness of this sheet varies greatly; on the Kei it is as much as 900 feet thick near Mimosa Dale, where both the top and bottom are seen in the cliffs. On the Kobonqaba River below Nyntughà it is at least 500 feet thick, but about five miles to the north-east, east of Nquise, it thins out completely.

A sheet about 100 feet thick, and apparently unconnected with any other sheet, underlies the village of

Kentani and the hill of that name about five miles north of the village; the outcrop appears at the edge of the Kentani escarpment and extends some five miles westwards on the southern face, and about eight miles north-east round the headwaters of the tributaries of the Kobonqaba.

Near Gentuli and Nqundwyu stations there are two sheets, one is low down near the Kogha River, and the outcrop of the other winds round the slopes about 500 feet higher up. Both these sills are continued in Willowvale, over the left bank of the Kogha.

The last and uppermost sill that needs to be mentioned is the N'Hlambe sheet, which covers a considerable extent of ground in the north-western corner of the Division; it is cut through by the Gcua River, but is continued far into Butterworth on the east side of that river, and also into Idutywa and Willowvale to the north and north-east. The greatest thickness seen is about 500 feet, near the Gcua, but it is considerably thinner south of Hughes' beacon. This sheet is cut through by the northern gap-dyke between Tutugha and Gobogobo.

The east and west dykes that traverse the Kentani Division are very remarkable ones; they extend from the Kogha mouth to the Gcua River, and can be followed across the Kei into Cathcart. From a certain point on the road between the Kei Bridge and Toleni, not far from the Eagle's Nest, a fine view can be obtained along the valleys weathered out along the course of the dykes; on the west a long line of valleys with low cols between each pair can be seen on either side of

the Kei, and to the east a similar line of valleys stretches for many miles between slightly higher ground. The dykes are made of a rather coarse rock composed of augite, hornblende, red mica, plagioclase, orthoclase (in micropegmatite), and quartz, with ilmenite, apatite and zircon as accessory constituents. The rock can be called an augite-mica-diorite. The coarse diorite weathers more readily than either the sedimentary rocks or the dolerite through which it passes, consequently the minor streams in its neighbourhood have worked their ways along it rather than through the more resistant rocks, with the result that a series of valleys with low cols between each pair have been formed. These are called "gap-valleys"[1] from the local name of "Transkei Gap" given to the whole series of valleys by the early surveyors and residents in the Transkei.

From several spots in the district, such as the N'Debe nek, Gobogobo, Cat's Pass and Lusizi the curious feature can be well seen, and it gives one the impression that a great gouge has been driven along the surface of the plateau and a strip removed. The width of the dykes is at the most about 400 feet.

There are two of these gap-dykes in Kentani, lying parallel and about a mile apart, but they cross, or join and separate again, in the N'Debe Valley. The northern dyke is not continuous on the surface between the Gentuli River and Cat's Pass, but the separate parts are very probably connected underground. The longest valley along the southern dyke is that of the

[1] The gap-valleys of the Transkei have been described in detail in the *Trans. S. A. Phil. Soc.*, Rogers and Schwarz (02).

Kabakazi and the lower part of the Kogha, in all about ten miles long.

The intrusion of these dykes was certainly later than that of the dolerites, for they cut through the latter. In its nature and composition the rock forming them is intermediate between the ordinary olivine dolerite and the granophyres mentioned in connection with the Kobonqaba sheet. None of the minerals or structures in the diorites are entirely foreign to the dolerites, and the diorites contain much less quartz and micropegmatite than the granophyres. Olivine is the only constituent of the dolerites that is absent from the diorites and granophyres.

The gap-dykes must be regarded as a late product of the same molten rock magma that supplied the dolerites; the more basic portion, represented by the dolerites, was got rid of, and a part of the more siliceous residual matter was extruded after the dolerite sheets had solidified; in many places the gap rocks cut through the dolerite as well as the sedimentary rocks, and have solidified as the augite-mica-diorite in the gap-dykes.

A large mass of very acid rock later than the dolerite sheets forms a considerable part of Gonubie Hill in Komgha, it is a microgranite consisting of quartz, orthoclase, and black and white mica. Near Komgha, on the main road to the Draaibosch outspan, there is a large quarry opened up in a thick sheet of dolerite through which run two veins of a granitic rock. The veins are eight inches wide at the most and can be followed downwards as far as the depth of the quarry allows. They are sharply defined and were evidently

injected after the dolerite became solid. Under the microscope they are seen to consist of a mixture of quartz and orthoclase with a granophyric (micropegmatitic) structure, in which lie aggregates of chlorite, pseudomorphs after biotite.

In the west of the Colony the dolerites frequently contain patches of a granophyric intergrowth of quartz and orthoclase; in many cases these are not in the form of dykes or veins, but occur as constituents of the ophitic dolerites without olivine. In Calvinia and Sutherland some large masses of granophyric rock have been found which are probably of the same nature as the dykes and veins in the Transkei.

In Pondoland and East Griqualand there are some very large masses of dolerite much thicker in proportion to their area than any of the sheets hitherto mentioned. The Tsala hills near Lusikisiki are small examples of these masses, and larger ones are N'tabankulu, Insiswa, Mount Ayliff, Mount Currey and the Ingeli Mountain. These seem to be thick lenticular or cake-shaped bodies of rock, but their structure is not known in detail. The sedimentary rocks near them do not appear to be disturbed, but it is evident that the intrusion of a mass about 1,000 feet thick, such as the Insiswa dolerite, and of no very great horizontal extent, perhaps five miles by two, could not have taken place without the displacement of a corresponding volume of sedimentary rock, a disturbance that should leave its effects upon the dip of the beds for some distance from the igneous rock. The only alternative to the displacement of the surrounding rock is the absorption of it by the liquid dolerite, but this

is a quite untenable supposition on any but a very small scale, which would not explain the phenomena. The dolerites are so uniform throughout the Colony, and inclusions that might be looked upon as remnants of the dissolved sedimentary rocks are so rare, that the molten rock cannot have dissolved the beds it displaces to any considerable extent.

In the higher parts of the Eastern Province thick dykes of dolerite sometimes form more or less circular outcrops. Mr. Dunn found several of these annular dykes hundreds of feet in width enclosing tracts of country some miles in diameter between Windvogel Berg and Queenstown. Mr. Schwarz describes a horse-shoe shaped dyke in Matatiele, and Mr. du Toit found a somewhat irregularly shaped closed dyke round Cala; the latter dyke coincides in position with a ring-shaped fault, the rock inside the ring has been lifted up relatively to that outside. A similar feature exists at Indwe.

As a whole the dolerites are of remarkably uniform composition. The constituent that is most variable in amount is olivine. In addition to the plagioclase, augite, olivine and iron ores that form the bulk of the dolerite, biotite is almost always present, sometimes in considerable quantity, and original hornblende is not seldom met with either independently or in close connection with the augite. The structure varies in one and the same sheet; the bulk of a thick sheet has an ophitic structure, that is the plagioclase crystals are to a greater or less extent enclosed by the augite, but near the edge of the sheet the augite is granular or forms rather imperfect

crystals. In thin dykes and sheets the structure is distinctly porphyritic, crystals of olivine, augite and plagioclase lie in a fine-grained matrix of augite grains and very small plagioclase crystals, often with a considerable amount of brown glass. Occasionally an almost pure glass, tachylite, is found at the contact of a sheet or dyke with the surrounding rocks or in the form of thin dykes traversing the dolerite or the sedimentary rocks. Tachylite is a black substance with a glassy appearance ; it looks not unlike bright bituminous coal, for which it has often been mistaken in this country. The greater specific gravity and hardness of the tachylite, however, distinguish it at once from coal. Porphyritic crystals of augite and plagioclase may occur in the tachylite, and the glass is sometimes converted into an opaque stony material along joints. Both the tachylite and the glassy dykes and sheets owe their peculiarities to rapid cooling. The thick sheets of dolerite naturally took a longer time in cooling than the smaller bodies of molten rock, and consequently the minerals were able to develop more thoroughly in them than in the latter, so the rock as we see it now is coarsely crystalline in the one case and finely crystalline or glassy in the other. The fact that the well-formed crystals of olivine that are often abundant in the coarse dolerites and absent from the fine-grained and glassy dykes points to the fact that the molten rock which forms the latter has been squeezed out of a partly consolidated dolerite in which the large olivine crystals were retained by the partly formed plagioclase and augite.

The questions of the origin of the dolerite intrusions and of the means whereby they were able to force their way between and through the sedimentary rocks are at present beyond our knowledge. The dolerites are quite different in nature from the great intrusions of granite and gneiss that invaded the Pre-Cape rocks, the sources of which were presumably exhausted before the deposition of the Table Mountain sandstone. The close connection of the dolerites in East Griqualand with the volcanic group at the top of the Stormberg series, in spite of the absence of brown mica and hornblende from the lavas and dykes of Matatiele[1] seems to indicate a common origin of the two groups of rock; the one consolidated below ground and the other at the surface. Some of the dolerites were certainly intruded after the formation of the Stormberg volcanic and sedimentary rocks, for quite typical members of the intrusions traverse those beds; it is not assuming too much to suppose that the whole of the dolerite sheets and dykes of the Karroo region belong to one period of igneous activity, so that the later limit to their age is fixed by the occurrence of boulders derived from thick sheets in the Embotyi conglomerate of the Pondoland coast, probably of Upper Cretaceous age. The Uitenhage conglomerates have hitherto been found only at a considerable distance from dolerite outcrops, so the absence of boulders of that rock from those conglomerates throws no light on the matter. At present it is uncertain whether the intrusions ceased with the volcanic activity of the latter part

[1] Schwarz, *Geol. Comm.* (02), p. 66.

of the Stormberg period or whether they continued after that period, but the evidence proves that some great intrusions took place after the Stormberg sedimentaries were deposited and before the formation of the Embotyi conglomerates.

During the Stormberg period there must have been an enormous mass of basic rock material lying at an unknown depth beneath the surface of the South African area ready to burst its bonds and rise towards the surface when favourable conditions prevailed. What those conditions were is at present a subject for speculation rather than for statement. It may be noted in passing that the mountain building in the south and south-west had probably then reached or passed its maximum, and that the great forces exerted in that process cannot but have influenced the fluid or potentially fluid rock magma. The remarkable freedom from disturbance of the sedimentary beds near even the larger sheets and dykes gives one the impression that the igneous rock made its way along channels that were ready to receive it rather than forced a passage through resisting rock. The immense areas over which some of the sheets extend without very great variation in thickness—the lowest sheet in Calvinia, for instance, certainly extends over an area of 3,000 square miles and probably a third more[1]—prove that the rock must have been in a very fluid condition, and that the enclosing sedimentary beds offered but little resistance to its progress.

It is difficult to form a satisfactory estimate of the

[1] *Geol. Comm.* (00), p. 50.

thickness of the rock overlying any particular sheet at the time of its intrusion, but a minimum estimate can be made in the case of the lowest Calvinia sheet, which lies near the top of the Dwyka series in the middle portion of its outcrop. It was certainly injected at a time when the Roggeveld escarpment was not in existence and the rocks now exposed on that escarpment stretched far to the west of their present position. These beds are over 2,000 feet thick, and to this must be added the unknown thickness of the Beaufort and possibly higher beds that have been removed by denudation since that part of the country was exposed to the air. Where the uppermost sedimentary rocks of the Karroo formation are still preserved, as in the Stormberg region, the difficulty of estimating the thickness of the cover at the time of the intrusion is little less than in the country further west, on account of the uncertainty as to the original thickness of the volcanic group and of the exact period of the intrusion during or after the volcanic outburst.

The position of the greatest total thickness of dolerite is at present unknown. At places on the Nieuweveld escarpment there is as much as 800 feet of dolerite in a total of about 3,000 feet of rock exposed in an almost vertical section, and similar proportions of dolerite to sedimentary rock have been noticed on the Roggeveld cliffs. In a deep bore hole at De Aar over 400 feet of dolerite were traversed within 1,600 feet from the surface; in the Transkei an even greater proportion of igneous to sedimentary rocks is present in the steep banks of the Kei and some other rivers, but the total depth of these

sections is rarely over 1,000 feet. The inclination of the sheets exposed south of the main watershed of the Colony is, on the whole, towards the watershed, but a similar relation has not been made out in the case of the northern sheets, which are not well enough known to allow of a general statement being made as to their behaviour.

The emergence of the Karroo formation from the central portion of the basin probably took place about the close of the Stormberg period or a little earlier; this emergence seems to have given rise to the east-north-east watershed that is now the main water-parting in the Colony. The intrusion of the dolerite sheets may have added to the height of the surface by arching it upwards, but to what extent cannot yet be decided.

At the contact of the dolerite sheets and dykes with the sedimentary rocks there is generally a noticeable hardening of the latter through a distance varying with the thickness or width of the intrusion.

In the case of sandstones the contact rock is hard and splintery like a quartzite, but, excepting epidote, new minerals seem rarely to be formed; the rock becomes harder by the cementing together of the constituent grains by quartz. The epidote gives the green colour to the contents of the small cavities found rather abundantly in argillaceous sandstones and mudstones which are traversed by dolerite. Epidote is a silicate of alumina and lime, and is only formed in those sandstones that were originally calcareous. The presence of the amygdale-like bodies of epidote and quartz in the impure argillaceous rocks near dolerite is very characteristic, and has been

noted in many districts between Calvinia and the Natal border. Cavities with remarkably smooth surfaces, identical in appearance with the steam-holes in lavas, were formed probably by the conversion of the water held in the then soft sediments into steam, and these spaces were subsequently partially filled by the epidote and other minerals formed by heated water vapour acting on the constituents of the surrounding sediments. The calcareous concretions in the shales are sometimes converted into epidote, but the lime-silicate wollastonite has not been noticed in the zone of altered rocks near the dolerite. Shales and mudstones are often changed into hornstone, a hard almost glassy-looking rock, which breaks with a conchoidal fracture; the typical hornstone is only a few inches thick, and passes gradually into the usual type of rock within about two feet of the dolerite. The hardening effect of the dolerite often extends much farther than any other change in character. A very marked example of this is shown in Plate XVI., a view of the junction of a thick dolerite sheet with the Dwyka conglomerate on the farm Dwas Douw in the Doorn River Valley, Calvinia. The rough-looking rock in the upper part of the cliff is the dolerite, and the well-defined columnar rock, forming a vertical krantz fifteen feet high, is the conglomerate. The lower end of the columnar layer is sharply marked, and below it the conglomerate is the usual sandy mudstone containing numerous boulders of many varieties of rocks. The photograph was taken at too great a distance from the krantz to allow the boulders exposed on the joint faces to be seen. The joints that divide the conglomerate into

such regular columns traverse boulders and matrix alike, without deviation.

The larger intrusive sheets of dolerite frequently show a rough columnar structure. Many examples of this can be seen in the sheets which crown the Nieuweveld escarpment in Beaufort West. The sill at the top of Tafel Berg, in Beaufort West, is divided up into columns over 300 feet in length, and from ten to thirty feet in diameter, but they do not traverse the whole thickness of the sill (400 feet).

The country occupied by the dolerite sheets is, as a rule, more fertile than that formed by the sedimentary rocks alone, for the dolerite contains valuable food materials for plants which are set free during the slow decomposition of the rock by the action of the weather and the damp soil. It is only in the eastern portion of the Colony that full advantage can be taken of the valuable soils derived from the dolerite, for large areas of that rock are there covered with fairly deep soil, and unweathered lumps of dolerite are rarely met with in the soil itself. In the arid central and western districts the soil cannot accumulate rapidly enough to clothe the unweathered rock, for it is not held together sufficiently by grass and other plants to prevent its being washed away by the occasional heavy rains. In the place of the extensive, rich grass-covered plateaux of the east, we find extremely rocky ground sparsely dotted over with small bushes, and yielding grass only for short periods after rain. On Plate XVII. is reproduced a photograph of typical dolerite country behind the Nieuweveld escarpment. The innumerable blocks of stone are pieces of

[illegible] omerate produced [illegible] he columnar rock [illegible] feet high. Dwas [illegible]

dolerite with a very thin crust of weathered rock; the blocks are mostly subangular at this spot, but they are often well rounded owing to the strong tendency to spheroidal weathering that is characteristic of the dolerite. Thousands of square miles in the Upper Karroo are covered with boulders like the foreground in Plate XVII., and the ground is exceedingly troublesome to traverse, either on foot or on horseback, unless one rides a horse born and bred in its neighbourhood.

The colour of the dolerite hills is usually dull red, but extraordinarily vivid crimson and yellow patches are often met with which are due to a lichen growing on the weathered crust of the rock. In certain localities, particularly the krantzes of the dolerite-capped hills in the southern part of the Upper Karroo, the dolerite assumes a blood-red tint when the sun is near the horizon, but this gives place to a duller colour when the sun stands higher.

The most exposed surfaces of large dolerite boulders in the drier regions become coated with a very thin film of deep brown or black material which has often a well-polished appearance. This thin coat seems to be chiefly composed of hydrated oxides of iron derived from the rock immediately beneath it. Dolerite is not the only rock that becomes covered with this dark and shiny film in the dry parts of the Colony. The harder and fine grained portions of the Karroo sandstones behave in the same way, and beyond the limit of the Karroo basin the hard Pre-Cape rocks, both of sedimentary and igneous origin, are often seen to be blackened and polished after long exposure. The implements fash-

PLATE XVII.—Surface formed by a dolerite sheet in the Fraserburg Division, near the road between Fraserburg and Williston. The hills in the distance are also of dolerite.

ioned from the jaspery rocks of the Griqua Town beds by Bushmen or Hottentots, which may now be picked up on the surface in Prieska and to the north of the Orange River, usually have their upper surfaces covered with a polished film. It is not known how long a freshly broken rock must be exposed to the sun and air before assuming this character.

The dolerites do not seem to contain any minerals of sufficient value to attract the attention of miners. Copper pyrites is present in small quantities at some localities, and galena fills some very narrow veins in the Roggeveld sheets, but neither of these has been found in considerable quantity. Dolerite is very durable, but it is difficult to work and unsuitable in colour for most building purposes. It is excellent stone for road metal, but its very toughness seems to prevent its general use, for it is difficult to break up. Where roads can be made with the help of heavy rollers it is a very good stone to use.

CHAPTER VIII.

THE CRETACEOUS SYSTEM.

THE Cretaceous rocks in the Colony are divided into two main groups, the Uitenhage series and the Pondoland Cretaceous series. The two groups have not been found in the same district; their relative age is determined on the evidence of fossils alone. They both consist of rocks formed near a shore line, and at the base of each group there is a considerable thickness of coarse conglomerate. The Uitenhage beds cover rather wide areas in the folded belt between the Karroo and the coast, resting unconformably upon rocks of all ages between the Pre-Cape and the Ecca beds. The Pondoland series, on the other hand, occupies two narrow strips on the coast, faulted down against older rocks. The south-western strip is seen to rest unconformably upon beds that probably belong to the Ecca series. Rocks of the same age as the Pondoland beds are found in Natal and Zululand.

THE UITENHAGE SERIES.

In the typical area, the valleys of the rivers flowing into Algoa Bay, this series has been subdivided into the following groups :—[1]

[1] This classification is substantially that of the late Dr. W. G. Atherstone.

Sunday's River beds -	**Clays, shales and sandy limestones with marine fossils.**
Wood beds - -	**Yellow sands, shales and limestones with a few marine shells and numerous plants.**
Enon beds - - -	**Sandstones, marls and conglomerates.**

The Enon beds are found at the base of the series throughout the district, but the thickness and nature of the rock differ very much within rather short distances. In the upper part of the Zwartkops River the Enon beds attain a very considerable thickness, as is also the case near Enon; but near Blue Cliff Station the conglomerate lying between the sandy and argillaceous rocks of the Uitenhage series, and the surface of the older rocks below, the Bokkeveld beds in this case, is at most only a few feet thick, and at places it is entirely absent.

The Enon beds are here taken to include the Zwartkops sandstone and variegated marls of Atherstone's classification,[1] for the conglomerates are so intimately connected with rocks agreeing with Atherstone's description of these two subdivisions that it is convenient to group the three together. There is indeed much reason to believe that the three subdivisions of the Uitenhage series are to be regarded more as three kinds of deposit formed under different circumstances, but at about the same time, than as successive groups of deposits. In any one spot, such for example as Wolve Kraal on the Sunday's River, the marine Sunday's River beds may be underlain by the Wood beds and

[1] Atherstone (57).

those again by the Enon, but there is evidence that even in the Uitenhage area rocks like the Enon beds were formed during the deposition of some of the Sunday's River beds. On the hill west of the native location at Uitenhage there is a small thickness of grey shale and limestone, containing marine fossils, interbedded with red sands and gravels belonging to the Enon type, although to the east of Uitenhage these marine strata are not found interbedded with conglomerates or sands of the Enon type. The sands and pebble beds west of the native location at Uitenhage lie against a rather steeply inclined slope of sandstone and quartzite belonging to the Table Mountain series, evidently the shore during a certain stage of the deposition of these rocks. The sands and conglomerates are the deposits formed near the shore, or in most cases probably in steep-sided inlets, drowned valleys in fact, which bordered the sea in which the Sunday's River beds were laid down. The marine beds intercalated with the red beds near the location represent a period of extension or encroachment of the sea on the land-locked inlet in which the red beds were formed.

In the Uitenhage district, then, we find that the Enon beds cannot be regarded as merely the earlier deposits of the Uitenhage period. As far as our knowledge goes they certainly were the earliest of these deposits, but their formation continued during the laying down of the marine clays and limestones of the Sunday's River beds along the shores of the sea in which the latter were deposited. In the country farther

west there is corroborative evidence of this, as we shall see later.

Fragments of wood with a charred appearance, very different from the petrified wood in the Wood beds, occur frequently in the Enon beds, and up to the present time these are almost the only organic remains known from the typical Enon beds in the Uitenhage area.

At Enon, which is situated in a kloof under the Zuurbergen, the conglomerate forms high hills which are curiously carved into crags and caves by the action of the weather on the conglomerate, harder in some places than others. The pebbles, usually about three inches in length and well rounded, were evidently chiefly derived from the Zuurberg quartzites (of Witteberg age). The matrix in which the pebbles lie is reddish and sandy.

In the upper part of the Zwartkops Valley the conglomerates are very thick, over 1,000 feet, and the same is the case at Hankey in the Gamtoo's Valley. They are overlain as a whole by the beds called Zwartkops sandstone and variegated marls by Atherstone, but conglomerate bands are not infrequent in these higher beds. On the right bank of the Zwartkops River below Uitenhage the red clays are worked for brick and tile making. The thickness of conglomerate below these clays and sands is very slight to the south of Uitenhage, where the Humansdorp Road leaves the Zwartkops Valley, but the clays and sands contain thin beds of conglomerate. In the clay pits belonging to the Port Elizabeth Brick and Tile Company near Despatch

Station some bones have recently been found, but they have not been determined.[1]

In the Bezuidenhout's River Valley from a short distance above Blue Cliff Station to a point some four miles above the railway bridge, the rocks lying below the Wood beds are well exposed at intervals along the river banks. They are reddish yellow sands, red clays and thin sandstones, with occasional pebble beds. Conglomerates like those of Enon are entirely absent from this valley. Near the fortieth milestone on the railway between Uitenhage and Blue Cliff, greenish sandstones very like some that occur in the Bezuidenhout's Valley, lie against slates belonging to the Bokkeveld series, without the intervention of any conglomerate.

The Wood beds are found overlying the Enon in the northern part of the area, and are especially well seen between Blue Cliff Station and the Witte River below Enon. The valley of the Bezuidenhout's River below Blue Cliff lies entirely in the Wood beds, and both above and below its confluence with the Sunday's River the rocks are well exposed in the bed of the latter river. The total thickness of the Wood beds in this locality may be as much as 1,000 feet. They consist of various sediments, sands, clays, hard limestones and sandstones, and well-laminated shales.

The base of the Wood beds in this valley is taken to be a loose yellow sandstone, seen in a cliff section

[1] Since the above was written Dr. R. Broom has seen these bones, and he informs me that they belong to Dinosaurians, reptiles that were previously unknown from the Uitenhage formation.

above Blue Cliff Station. Farther down the valley many large pieces of tree-trunks, one of which is twenty-five feet in length, are preserved in a clayey sandstone. These are probably the trunks of conifers, but no leaves or other parts of the trees have been found with them. Some of the wood evidently lay for some time in the water, for the shells of a small boring mollusc, *Gastrochæna dominicalis*, are found in it in considerable numbers. The only other animal remains discovered in these sandstones are oyster shells, and some fragile fragments of large bones, too imperfect to be named. In some hard limestone bands intercalated with the upper part of the sandstones there are numbers of shells of *Psammobia atherstonei*. Curiously twisted stems, which may have belonged to a cycad, occur in the upper part of the sandstones, as well as stems of *Benstedtia*.

The chief interest of the Wood beds lies in the well-preserved leaves and other parts of plants that are preserved in the bluish-grey sandy mudstones, clays, and thin limestones between Paltje's Kraal (on Bezuidenhout's River) and the lower portion of the Witte River, including the bed of the Sunday's River near the Dunbrody Mission Station.[1] Some of these beds are crowded with the broad fronds of *Zamites*, a cycad of which several species have been found; they are accompanied by other cycads, conifers and ferns.[2]

[1] Dunbrody is the Geelhoutboom of the Divisional maps, a name which is used by Atherstone, Tate and other writers.

[2] All the plants mentioned in this chapter are named according to Mr. Seward's determinations published in the *Annals of the South African Museum*, vol. iv., part 1, 1903. See also Tate (67).

The following is a list of the plants hitherto found in these beds :—

Ferns—

Onychiopsis mantelli, Brongn.

Cladophlebis browniana, Dunk.

,, *denticulata*, Brongn., forma *atherstonei* (found also at Herbertsdale).

Sphenopteris fittoni, Sew.

,, sp.

Tæniopteris, sp. (found also at Herbertsdale).

Cycads—

Zamites recta, Tate.

,, *morrisii*, Tate.

,, *africana*, Tate.

,, *rubidgei*, Tate.

Cycadolepis jenkinsiana, Tate.

Benstedtia, sp.

Carpolithes, sp.

Conifers—

Araucarites rogersi, Sew.

Taxites, sp.

Brachyphyllum, sp.

Conites, sp.

Coniferous wood.

The lowest fossiliferous beds seen on the Witte River contain *Onychiopsis mantelli*, but the beds containing coniferous wood and reptilian bones in the Bezuidenhout's River are probably lower than these. A section taken in an approximately north-east direction along the Bezuidenhout's and Witte Rivers from one side of the Uitenhage deposits to the other is by no means similar towards each end, owing to the much greater development of the conglomerates along the Zuurbergen.

The plant bearing beds pass upwards into bluish rocks containing marine fossils, but the whole of the

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yellow and brown coloured surfaces. The limestones are often crowded with shells, and some layers in the shales are composed almost entirely of the shells of *Exogyra imbricata*, and others consist largely of *Trigonia ventricosa* shells. Parts of the skeleton of a reptile related to *Plesiosaurus* have been obtained from the cliffs above Picnic Bush.

In the Sunday's River Valley below Addo Station higher marine beds seem to be exposed than are seen anywhere in the Zwartkops Valley. They have yielded a large number of fossils, amongst which *Crioceras spinosissimum* and *Hamites africanus* are the most interesting.[1]

The following is a list of the more important fossils from the Sunday's River beds, the letters S and Z placed after the names indicate their occurrence in the Sunday's River and Zwartkops Valleys respectively:—

PRINCIPAL INVERTEBRATA FROM THE UITENHAGE (MARINE) BEDS.

Cephalopods—	
Baculites, sp. - - - - - - - - -	Z
Belemnites africanus, Tate - - - - - -	S
Crioceras spinosissimum (Hausmann), Neumayr - -	S
Hamites africanus, Tate - - - - - - -	S
Olcostephanus (*Astieria*) *atherstonei*, Sharpe, sp. - -	S Z
,, ,, *baini*, Sharpe, sp. - - -	S
"*Ammonites*" *subanceps*, Tate (affinities doubtful) -	S
Gasteropods—	
Actæonina jenkinsiana, Tate - - - - -	S
,, *atherstonei*, Sharpe - - - - - -	S Z
Alaria coronata, Tate - - - - - - -	Z

[1] See Krauss (51), Tate (67), Holub and Neumayr (82), Bain (56) (appendix by Sharpe).

Gasteropods—*continued*—	
Monodonta hausmanni, Neumayr	
Natica atherstonei, Sharpe	Z
Neritopsis ? turbinata, Sharpe	S
Patella caperata, Tate	S
Trochus baini, Sharpe	Z
Turbo atherstonei, Sharpe	Z
,, *baini*, Sharpe	S Z
Lamellibranchs—	
Astarte herzogi, Goldfuss, sp.	Z
,, *longlandsiana*, Tate	Z
,, *pinchiniana*, Tate	S
Avicula baini, Sharpe	Z
Cardita nuculoides, Tate	S
Ceromya papyracea, Sharpe	Z
Corbula ? rockiana, Tate	Z
Cucullæa jonesi, Tate	Z
,, *kraussi*, Tate	S Z
Cyprina borcherdsi, Tate	Z
,, *rugulosa*, Sharpe	S
Exogyra jonesiana, Tate	Z
,, *imbricata*, Krauss	S Z
Gastrochæna dominicalis, Sharpe	S
Gervillia dentata, Krauss	S
Lima neglecta, Tate	S
,, *obliquissima*, Tate	S
Lithodomus stowianus, Tate	S
Modiola atherstonei, Sharpe	Z
,, *baini*, Sharpe	S
,, *rubidgei*, Tate	S
Mytilus jonesi, Tate	S
Parallelodon atherstonei, Sharpe, sp.	S
Pecten projectus, Tate	S Z
,, *rubidgeanus*, Tate	S
Perna atherstonei, Sharpe	S Z
Pholadomya dominicalis, Sharpe	S
Pinna atherstonei, Sharpe	S Z
Placunopsis imbricata, Tate	S
,, *subjurensis*, Tate	Z
,, *undulata*, Tate	S

Lamellibranchs—*continued*—	
Pleuromya baini, Sharpe, sp.	S
,, *lutraria*, Krauss, sp.	Z
Psammobia atherstonei, Sharpe	S
Ptychomya complicata, Tate, sp.	S
Seebachia bronni, Krauss, sp.	Z
Trapezium niventianum, Tate, sp.	S
Trigonia hertzogi, Goldfuss, sp.	S Z
,, *tatei*, Neumayr,	S
,, *vau*, Sharpe	S Z
,, *ventricosa*, Krauss, sp.	Z
,, *conocardiiformis*, Krauss, sp.	S Z
Polyzoan—	
Berenicea antipodum, Tate	S
Worm tubes—	
Serpula (several species)	S Z
Echinid—	
Cidaris pustulifera, Tate	Z
Coral—	
Isastræa, sp.	Z

The outliers of the Uitenhage series to the west of the division of that name do not contain any deposits similar to the Sunday's River beds so far as is known at present.

In the Gamtoos River Valley (Humansdorp) there are conglomerates and sandstones like those of Enon and the Zwartkops River.

In Knysna there are three basin-like areas of quartzites, sandstones, conglomerates and clay, belonging to the Uitenhage series; the pebbles are mostly of quartzite derived from the neighbouring hills and mountains made of the Table Mountain series. They occupy deep valleys cut out of the Cape formation, and are themselves cut through by the coast-line. Near the village of Knysna these beds are over 600

feet thick; the boulders in the conglomerate are often of large size, in places they average a foot in diameter. Along the Bitou River there is a great mass of conglomerates and loose sandy beds with pockets of lignite. The conglomeratic beds in the Bitou basin are peculiar in that the included fragments of rock are angular instead of being well rounded as is usually the case with the pebbles in the Uitenhage conglomerates. The third basin is in the valley of the Pisang River; the beds in it are less conglomeratic and more sandy and clayey than those of the other two areas, and some of the beds are quartzitic owing to the deposition of silica between the grains of the rock. Near Seal Point casts of *Trigonia conocardiiformis* have been found in the sandstones and conglomerates. This is the only marine fossil yet found in the conglomerates of the Enon type, but as it is a very characteristic member of the fauna of the Sunday's River beds its occurrence is of great interest. It is evident that the water in which the Pisang River beds were deposited must have been salt, or at least so near the sea that the shells of the dead bivalves could be washed back into it by strong tides. But the absence of marine fossils from the bulk of the Knysna conglomerates and sandstones can only be interpreted on the supposition that the rocks were laid down in water sufficiently far removed from arms of the sea to be free of marine inhabitants.

The occurrence, which has been already mentioned, of a bed of marine fossils between the red gravels and sandstones north-west of Uitenhage, proves that the sea at one time invaded the non-marine area, and the

Trigonia of the Pisang River beds points in the same direction. The *Trigonia* of Pisang River proves also that these rocks were formed at about the same time as the Sunday's River beds; whether the latter ever spread far to the west of their present limits must remain an open question, but there can be no doubt that the conglomerates and sands of the Enon type were being laid down in the west while the sea occupied the position of the lower part of the present Sunday's River Valley.

Still farther west, in the divisions of Mossel Bay, Riversdale, Robertson, Swellendam and Worcester there are large areas of conglomerates, sandstones, shales and mudstones, resembling to some extent the Enon beds but containing some varieties of sediments not met with in the Uitenhage Division; and again in the country between the Langebergen and the Zwartebergen, in the divisions of Willowmore, Uniondale and Oudtshoorn, there are large areas of similar rocks that in spite of the absence of fossils must be relegated to the Uitenhage beds.

All these masses of rock occur in a more or less similar manner; they occupy basins partly cut out of the older rocks, but in part due to earth movements subsequent to the Uitenhage period. They extend far below the present level of the rivers traversing them, and are generally elongated in an east and west direction, roughly parallel to the general strike of the older rocks.

The Mossel Bay area is perhaps the most interesting of these patches of Uitenhage beds, for it alone has

yielded fossils that can be compared with those of the Uitenhage district. It is rather irregular in shape, about fifty miles long from east to west, and at the most fifteen miles wide. The northern boundary is formed by the Langebergen, and the southern in part by the coast between Mossel Bay and Great Brak River, and, west of Mossel Bay, by the Bokkeveld and Table Mountain series. North of Mossel Bay the George granite and the highly altered Malmesbury beds project far into the area of Uitenhage beds, dividing its eastern end into two tongues which join west of the main road to Robinson's Pass. The Uitenhage beds thus rest upon granite, Malmesbury beds, Table Mountain sandstone, Bokkeveld and Witteberg beds at different places; it has been noticed that, to a certain extent, the pebbles and boulders, for the included blocks reach a length of more than eighteen inches in the conglomerates, came from the rocks that are close at hand rather than from those forming the mountains. Thus in the Ruitersbosch Valley there is a large proportion of granite boulders in the conglomerates which are well exposed round the western end of the George granite. Near Bottle's Kop, that curiously shaped hill of quartzite and quartz schist (probably belonging to the Table Mountain series), which is so conspicuous to the north of the Mossel Bay-George road, the conglomerate contains many fragments of the quartzitic rock. Along Weyer's River, and generally along the western border of the conglomerate, pebbles derived from the Bokkeveld beds are very abundant. At Cape St. Blaize the conglomerate is represented only by a very thin layer of breccia, composed of angular fragments of the under-

lying Table Mountain sandstone. Along the northern boundary Table Mountain sandstone pebbles are by far the most abundant, and this is also the case in the conglomerates lying at a considerable distance above the base of the Uitenhage beds, as at Honig Klip Kloof, where there are magnificent sections through a coarse, white conglomerate, composed almost entirely of pebbles and boulders of Table Mountain sandstone and quartzite; the Honig Klip Kloof conglomerates are interbedded with pale, sandy beds, and probably form about a half of the whole thickness, some 500 feet, exposed along the valley. The pebbles in the conglomerates are usually very well rounded; they must have been rolled about for a long time and reduced to their present form before being buried in the sandy or muddy matrix of the rock.

The beds of conglomerate are by no means confined to the base of the series; they seem to occur at intervals throughout the whole thickness of rock, and are separated by beds of shales, sands or mudstones.

The maximum thickness of the Uitenhage beds in Mossel Bay is rather considerable. They lie comparatively undisturbed, for the angles of dip are low; they certainly descend below sea level in places, and the bed of the Gouritz River, both just below the gorge through the Langebergen and to the north of Roode Hoogte lies in sandstone and pebble beds of this series; they form practically the whole of the hills between Herbertsdale and the watershed north of the Stink River. The tops of these hills are mostly formed by some twenty feet or less of the surface deposits resting unconformably upon the Uitenhage rocks, but as the average height

of the hills is over 1,000 feet the greatest thickness of the Uitenhage beds is probably rather over that amount.

At a spot about three miles east of the village of Herbertsdale there are some shales containing plant remains. Three species have been recognised amongst them, *Cladophlebis denticulata* forma *atherstonei*, which also occurs at Dunbrody in the Wood beds, *Tæniopteris*, also found at Dunbrody, and *Taxites*. The shales are very soft and easily weathered, so that the exposures are very few. The Herbertsdale outcrop has been opened up for prospecting purposes owing to the presence of small fragments of black lignite, which led to the expectation of a workable deposit of coal. No such reward met the searchers, but their work furnished the means of obtaining the three species of plants mentioned above. In a fairly well watered country like the Mossel Bay Division soft shales are usually covered up by soil and vegetation, and in the absence of quarries, pits and cuttings, it is extremely difficult to get out any fossils there may be in the rock. Although the Herbertsdale plants are almost the only ones yet found west of the Uitenhage district there must be many more awaiting discovery, and any further specimens will be of very great interest.

Many casts of parts of stems have been found in the hard sandstone of Cape St. Blaize, but hitherto none of them has been determined.

The underlying surface of the Cape formation and pre-Cape rocks is probably very uneven. In the Lang Touw Valley below Herbertsdale some sections are exposed, showing the conglomerates and sands of the

Uitenhage beds resting against a steep almost cliff-like face of Bokkeveld beds, the north slope of an old valley running east and west. The west end of the George granite is a high ridge reaching a height of perhaps 1,000 feet above the lowest visible portion of the conglomerates in the Brandwacht Valley to the south, and a less though still considerable height above the conglomerates between it and the Langebergen.

The sandstones of Cape St. Blaize, lying horizontally and unconformably upon the Table Mountain series, which dips steeply southwards, are much harder than the sandy beds of the Uitenhage series usually are, but not far to the west along the coast the beds are much softer, very like the sandy clays that occur north-east of Heidelberg. The Cape St. Blaize rocks form a narrow outlier lying east and west and are separated by about four miles of rough country of Table Mountain sandstone from the large area of Uitenhage beds, which are exposed at sea level near Hartenbosch.

The outlier of Uitenhage beds upon which the village of Heidelberg is built is about thirty miles long from east to west, and eight wide at its broadest part near the west end. It stretches from the west side of the Slang River in Swellendam to Assegaai Bosch in Riversdale, and both the Duivenhoek's and Kaffir Kuil's River traverse it without exposing the underlying rocks. The total thickness of the beds must be considerably over 1,000 feet, for they have a variable and low but on the whole northerly dip throughout, although owing to want of outcrops it is impossible at present to state how far the observed dips are due to subsequent move-

ments and to what extent they are original features. The conglomerates and sands may well have accumulated at moderate angles, and sections along the new railway between Heidelberg and Riversdale show masses of gravel piled up very irregularly and lying between sand and clays which are themselves false bedded. Such sections show that the sediments were deposited in water in which strong and varying currents prevailed. Much of the Heidelberg outlier, however, is composed of thin bedded shales and mudstones, which must have been laid down in quiet water, although thin pebble beds are frequently found with these fine-grained sediments. The outlier is certainly basin-shaped, and no connection has been traced with the Mossel Bay beds to the east, or with the Swellendam basin to the west. It is probable that subsequent earth movements have disconnected these basins of Uitenhage beds, aided of course by denudation, which has swept away perhaps the greater parts of the Uitenhage beds originally deposited in that part of the Colony.

The Heidelberg beds chiefly consist of conglomerates, sands, red and grey mudstones, shales and clays; near Heidelberg there are some peculiar hard white argillaceous beds, which are quarried for foundation stones, and with them some pale siliceous shales crowded with the thin shells of an entomostracan, *Estheria anomala*, Rupert-Jones, a fossil that is also found at many other places in the Heidelberg outlier, but hitherto not known from the Uitenhage district, or from any of the other outliers of the Uitenhage series. At Heidelberg village the clays exposed by the excavations for the railway

station contain the *Estheria anomala* and another entomostracan genus, probably *Cypris*; some badly preserved lamellibranch shells closely resembling the *Psammobia atherstonei* of the Uitenhage district have been found in the same beds. Some fish scales belonging to a ganoid genus, some indeterminable plant remains, and a wing case of a beetle complete the list of fossils from the Heidelberg outlier. It is certain, however, that a considerable variety of fossils will be found there in the future. The varied nature of the scanty remains mentioned above show that many classes of organisms were represented in the waters in which the Heidelberg beds were deposited, and only careful searching is required to produce good specimens. The most favourable localities for fossil hunting in that district seem to be the Doorn River Valley west of Heidelberg village, the Spiegel River Valley, and the Klein Vette River north-west of Riversdale, but in the course of time new exposures will be opened up along roads, and for various other purposes, in places where the rock underlying the soil cannot now be seen. With the two villages of Heidelberg and Riversdale to supply people whose curiosity is sufficiently aroused to make them look about the neighbourhood for fossils there should be a long list of them before many years have passed.

The beds in which the fossils have been found are grey or whitish in colour; the red clays, sands and marly beds seen to the north of Heidelberg have not proved fossiliferous. It is generally found that red-coloured rocks are not fossiliferous. The red colour is due to the higher state of oxidation of the iron com-

pounds than is the case in the green, blue and grey rocks; when much organic matter was present during the deposition of the mud, the red, highly oxidised, iron compounds were reduced to a less oxidised state, and these give a bluish-green, or grey colour to the mud. The amount of organic matter present was of course closely connected with the number of living organisms that might leave traces of their existence in the shape of fossils, hence it is always to be expected that beds that are uniformly red throughout, and therefore to be regarded as having been red when formed, should yield few or no fossils.

On the watershed between the Doorn and Klein Doorn Rivers the cuttings for the new railway line to Riversdale revealed the presence of some limestone bands showing cone-in-cone structure, and a few thin veins of gypsum. The cone-in-cone limestone breaks up in a very curious fashion; the rock appears to be built up of a number of cone-shaped bodies, closely pressed together, with their axes perpendicular to the bedding planes. The gypsum fills narrow cracks and joint planes, and is a product of the mutual decomposition of pyrites and carbonate of lime in the shales.

A very interesting point in the Heidelberg basin is the occurrence of a mass of melilite-basalt amongst the gravels and sands near the northern boundary of the area on the farm Spiegel River. The rock forms the top of a low hill on a ridge running south from Amandel Bosch Rug, and the outcrop is roughly circular in outline, with a diameter of not more than 300 feet. The boundary has not been exposed, so that the contact with

the Uitenhage beds is invisible. The presence of the conglomerates and sands in the steep kloofs on either side of the ridge, and on the surface both to the north and south of the melilite-basalt, and the absence of fragments of the latter from the conglomerates, prove that the igneous rock is surrounded on those sides by the conglomerates, and that it was very probably of later age than they. This evidence would be considered sufficient proof of the intrusive nature of the igneous rocks, as regards the Uitenhage beds, if similar intrusions were known elsewhere in those beds, but as this small mass of igneous rock is the only one known in the Uitenhage beds, an actual exposure of the contact would be very welcome. The form of the igneous rock is quite consistent with the supposition that it fills a pipe, a more or less cylindrical channel passing vertically downwards like the channels connecting volcanic vents with the source of supply below the surface; and the nature of the rock itself is not opposed to that idea, for it is a thoroughly glassy rock composed of crystals of olivine up to about a tenth of an inch in length, embedded in a ground-mass of small crystals of melilite, grains of augite, minute crystals of perofskite and magnetite, and brownish glass. Melilite-basalt is not a common rock, far less usual in volcanic districts than the less basic rocks containing felspar, and when the Spiegel River outcrop was found it had not been observed elsewhere in the Colony. Quite recently, however, melilite-basalts have been found in the Sutherland Division in close connection with pipes in the Karroo formation containing some of the rocks and minerals characteristic of the Kimberley diamond

pipes. In fact, it seems that the melilite-basalt of Spiegel River fills a pipe that is similar in nature to the pipes filled by the "blue ground" of Kimberley and other parts of South Africa. This resemblance, so much strengthened by the occurrence of melilite-basalt in the Sutherland pipes, will be discussed in a later chapter, where the bearing of the Spiegel River rock upon the age of the Kimberley pipes will be pointed out.

Near the village of Swellendam there is an isolated basin of Uitenhage beds. Its exact limits are not known, as it and the surrounding rocks belonging to the Bokkeveld-Witteberg series are much hidden by gravels and alluvium of a much later age, but it is about twelve miles long and five wide, and extends from the village, the eastern part of which is built on it, to beyond the Buffeljagt's River. The rock near the western end seems to be chiefly composed of conglomerates containing pebbles derived from the Malmesbury, Table Mountain, Bokkeveld and Witteberg series. At the railway station a bore-hole put down to the depth of 350 feet did not reach the bottom of the conglomerate. Near the lower part of the hole the bore passed through a boulder of micaceous slate seven feet in diameter. There are but few exposures of these beds, but the railway cuttings east of the village show that there are sandy clays interbedded with the conglomerates.

The Swellendam beds have generally a low, north-easterly dip, and the basin-shaped area occupied by them must in part be due to earth movements subsequent to their formation. The west end of the basin must have a very steep slope, for the slates forming the basin crop

out immediately west of the river that runs through the village at a much higher level than the railway station, which lies only a few hundred yards across the river, and where the bore hole did not reach the base of the conglomerates at 350 feet.

Two outcrops of red sandstone and conglomerate occur in the bed of the Groot Vader's Bosch Stream and on the hill just south of it, where the main road leaves the valley; these outliers are situated between the Swellendam and Heidelberg basins and point to the former connection of the beds filling them; a minute examination of the district, with particular attention to all excavations and cuttings that may be made, will certainly prove the greater extension of the Uitenhage beds in this area.

In the country south of the Zwartebergen the gravels and other deposits belonging to a comparatively recent period often hide the underlying rocks, and in some cases the gravels may be mistaken for the Uitenhage conglomerates. With the high level gravels there are often associated compact rocks whose grains are cemented together by silica, carbonate of lime, or ferruginous matter, and when once a person is well acquainted with these somewhat peculiar rocks he can readily recognise them in even very small fragments; their presence in a gravel at once distinguishes it from the Uitenhage conglomerates. The high level gravels themselves can usually be distinguished from the Uitenhage beds by the fact that they cover flat hill tops, often bounded on one or more sides by a low step or krantz, due to the gravels offering more resistance to

the weather than the underlying rock, whether the latter belong to the Uitenhage beds or the Bokkeveld or Witteberg series. In the Mossel Bay basin excellent sections showing the unconformity of the gravels and surface quartzites to the Uitenhage beds can be seen in the valley of the Nauga River east of Herbertsdale; a fine example of a similar unconformity in the Willowmore Division is shown on Plate XIX.

West of Swellendam there are two more isolated basins of Uitenhage beds, one stretches from Robertson to Ashton, and the other from south of Goudini Road Station to beyond Nuy, passing just south of Worcester. The beds exposed in these basins are red conglomerates, containing pebbles from all the rock series from the Malmesbury to the Ecca, which crop out within short distances of the Uitenhage beds. The latter rest upon the older rocks both to the south and north of the Worcester fault, and are apparently unaffected by the fault, which must consequently have been in the same state in Uitenhage times as it is to-day. The conglomerates are well exposed on the banks of the Kogman's Kloof River above Ashton Station; on the road to Waai Kloof from Worcester, and in a railway cutting just outside Worcester Station.

Between the Langebergen and Zwartebergen a very considerable tract of country in the divisions of Oudtshoorn and Willowmore is occupied by the sandstones and conglomerates of this series. The longest area extends from the west or right bank of the Gamka River below Calitzdorp to near Tover Water Poort, a distance of over seventy miles, but near Meiring's

Poort the width of the area is very small, under a mile; south of Coetzee's Poort the width is over twelve miles. Along the northern edge of the area the conglomerates lie directly upon the Cango series; but east of Meiring's Poort they rest upon the Table Mountain Sandstone along the northern edge, and upon the Table Mountain and Bokkeveld series on the south. The Olifant's and Gamka Rivers flow for a considerable distance in rocks belonging to this series.

The conglomerates between Coetzee's and Potgieter's Poorts closely resemble those at Enon. They are red rocks, and weather into curiously rugged crags with numerous small caves, and at places two caves on opposite sides of a crag have met, with the result that the crag has a hole through it. These conglomerates were deposited against steep banks formed by the older rocks. The conglomerates as a whole lie at the bottom of the basin, or rather they crop out on its edge, and are probably continuous under the sandstones and shales that occupy a wide area within the basin. Very probably the conglomerates were in part formed near the sides of the valley while the finer grained sediments were being deposited farther away from the hills. Although the conglomerates are chiefly found in the peripheral portion of the area they are not confined to it, for near Oudtshoorn thick beds of conglomerate occur at a much higher level than the sandstones on which the town is built. The sandstones are seen between Calitzdorp and Vlakte Plaats, and at the town of Oudtshoorn, where they are much used for building purposes. They are rather soft sandstones, not quartzitic,

and are usually greenish in colour. The sandstones and shales contain bits of fossil wood, and near Vlakte Plaats masses of lignite sufficiently large to be dug out and used for fuel have been found, but this lignite, as is the case with similar materials elsewhere in the Uitenhage beds, near Herbertsdale and in the Sunday's River Valley, is not found in layers that are thick and constant enough to repay systematic working.

No determinable fossils have been found in the Oudtshoorn and Willowmore basin.[1]

The depth to which the Uitenhage beds in this basin extend below the surface is not known.

Many small outliers of conglomerates and sandstones belonging to this series occur to the east and south-east of the Oudtshoorn-Willowmore basin, in the valleys of the Olifant's and Baviaan's Kloof Rivers.[2] The beds often have considerable dips, and appear to be the remnants of deposits that filled up these valleys before the present rivers re-excavated them. The original form of the deposits modified by subsequent earth movements and denudation are jointly responsible for the small detached basins that are now observable.

There is still very much to be learnt about the nature and distribution of the Uitenhage beds in the Colony; the Uitenhage district itself has yielded but a small part of its history, although it has attracted more attention from geologists than any other area in the Colony, excepting perhaps the Cape Peninsula and the Diamond

[1] Since this was written Mr. Muller Rex has sent two Dinosaurian teeth from the Oudtshoorn sandstone to the S. A. Museum.

[2] A description of these outliers by Mr. Schwarz will be found in *Geol. Comm.* (03).

Fields. At present the limits of the marine beds are not known exactly, nor have any outliers of them been discovered, although it is very likely that they exist to the east if not to the west of the Uitenhage area.

At the commencement of the Uitenhage period the southern parts of what is now Cape Colony must have been very mountainous. Great valleys with mountains towering on either side stretched east and west for long distances, and so far had denudation proceeded that all the rock series from the Pre-Cape to the Karroo formation were exposed at the surface. The height of the mountains above the bottom of the valleys was greater than it now is; allowing for earth-movements subsequent to the Uitenhage period that have in some cases at any rate brought about the depression of the valleys, the amount of rock removed from the mountain ridges since the beginning of that period must be very considerable, since it includes a large part of the material now forming the Uitenhage beds as well as that removed since the close of the period. The rivers, which before that time were able to carry away the mud, sand and pebbles delivered to them by the mountain streams, became unable to cope with their work, and their beds consequently became choked up with debris, at first as a rule of a coarse nature including many large boulders and pebbles together with a large quantity of sand. These accumulations are the conglomerates that lie below the fine grained rocks, the Enon beds of the Uitenhage district and the similar rocks of the outliers to the west, but it is by no means certain that the red conglomerates round the Oudtshoorn-Willowmore basin,

for example, were formed at precisely the same time as the Enon conglomerate itself. One possible cause of this change of conditions, the change by which the area became one of deposition or accumulation instead of a region in which the destructive agencies had full sway, may have been that the level of the land surface as a whole was reduced with regard to the level of the sea into which the old rivers flowed. Whether such a downward movement of the land took place uniformly or whether some parts were depressed more than others is not easy to determine, although the fact that the marine beds have not been found west of Knysna seems to point to an unequal distribution of the change in level. Had the sinking gone on continuously and equally over the whole area we should expect a gradual extension of similar sediments from the sea landwards, *i.e.*, conglomerates at the bottom, then fine grained rocks of fluviatile origin, and, finally, marine beds on the top. During the uniform and gradual depression of a tract of country, in the course of which the actual grade or inclination of the river valleys would not be altered, those parts of the valleys left above the level of the sea at any one time would naturally be able to carry on their work as they did before the downward movement set in. In the case of the Uitenhage beds, however, the state of affairs is quite different, no such regular spreading of the deposits from the marine area is noticeable; on the contrary the Uitenhage district is the only one where a series of conglomerates, fluviatile sands and muds and marine beds has been observed, and even there the red conglomerates and sands near the native

location at Uitenhage are intercalated with by no means the lowest of the marine beds, showing that a part of the shore of the sea lay round the end of the mountains near Uitenhage some time after the earliest marine beds were formed in the neighbourhood. If the sea ever reached the western outliers of Oudtshoorn, Heidelberg and Swellendam, no trace of its presence has yet been found, and in any case over 1,000 feet of non-marine sediments were piled up before it did so. These filled up the old valleys to the extent of at least 1,000 feet, very probably to a much greater depth, possibly above the level of the lowest passes over the Langebergen and Zwartebergen. If the movement which allowed the sea to gain access to the Uitenhage district can be shown to have been unequal, so that the lower portions of some of the east and west valleys were raised, the formation of the basins, as well as the gathering in them of such large quantities of conglomerates, sands and shales will be explained.

There is, however, another possible cause which would account for the old rivers receiving more debris than they could carry away, and that is the coming in of a drier climate than had formerly prevailed.[1] Under such conditions the supply of rock debris would be as great as, if not greater than, during the preceding moister period, for the hills would be less protected by vegetation, and the breaking up of the naked rock by change of temperature would proceed rapidly. The

[1] For an excellent account of the rocks formed under desert conditions, such as here spoken of, the student able to read German should peruse Professor J. Walther's *Denudation in die Wüste.*

occasional rain storms in such a climate sweep down vast quantities of gravel and sand, rounding off the edges of the rock fragments and thus producing pebbles and boulders of the ordinary shapes. The prevalence of unfossiliferous red-coloured conglomerates and sands, especially near the base of the series, in Uitenhage, Oudtshoorn, Heidelberg, Swellendam, Robertson and Worcester, supports this explanation; and the irregular piling up of much of the red rocks is evidence in the same direction.

The grey shales and muds of the Wood beds in the Uitenhage Division were probably formed in the waters of a river that had direct communication with the sea, for the oyster shells, the *Gastrochæna* in the logs of wood, and the *Pecten*, all found in the Wood beds near Dunbrody, point to the proximity of the sea. The plant-bearing shales near Herbertsdale, and the grey shales with *Estheria* and the other fossils previously mentioned in the Heidelberg area, have not yielded any proof that the water in which they were laid down was in close proximity to the sea. These beds may have been formed in shallow lakes or lake-like expansions of the river which still drained the country. It cannot be held that the valleys were entirely closed, that they were in a region that had no outlet to the sea; for in such districts the salts that are contained in small quantities in all rocks become concentrated in the water that temporarily or permanently occupies the lowest levels, and form layers of crystalline rock-salt, gypsum and other minerals that are interbedded with the sand and mud carried into the same basins.

No traces of such minerals have been met with in the Uitenhage beds,[1] and their absence is good evidence against the supposition that the isolated basins of the Uitenhage outliers were originally entirely without outlet to the sea.

The description of the outliers on previous pages shows distinctly enough that the deposits vary considerably from one basin to another, that although their general nature is very much the same, the order in which they occur is not in the least identical. The position of the outliers also shows that they were formed in separate valleys, in each of which the deposits were governed by the local conditions. Whether during the later part of the period, represented by beds that have mostly been swept away by denudation, all the outliers were connected, and sediments were spread over the whole of the district in which the outliers occur as well as beyond its limits must be left to the future to decide. It is quite possible that evidence sufficient to settle the question will be forthcoming.

Whether this was the case or not, the absence of transverse valleys in the Langebergen filled with the Uitenhage beds is specially worthy of note, for it shows that the Oudtshoorn basin was then quite distinct from the valleys south of the Langebergen, and that the rivers which now traverse that range had no existence in those days. The Uitenhage beds both north and

[1] The gypsum of the Heidelberg outlier is evidently derived from the shales by the mutual decomposition of some of their components. Since the above was written Mr. Schwarz has found gypsum in some of the Willowmore outliers; see *Geol. Comm.* (03), p. 114.

south of the Langebergen extend below the present level of the Gamka-Gouritz River bed, and the dislocations undergone by the Uitenhage beds in those areas do not seem to be great enough to account for the complete isolation of the beds on either side of the mountains; the sharply defined gorges of the Gouritz River through the Gamka hills and Langebergen seem to have been cut since Uitenhage times, for they contain no outlier of the rocks that one would expect to find had they been of pre-Uitenhage age.

Considering generally our present knowledge of the Uitenhage beds, it leads to the conclusion that the depression of the area as a whole, which allowed the sea to encroach upon the previous land surface in the Uitenhage district, was not uniform, but that the grade of some of the valleys was at the same time altered, and that this may have been accompanied by a drier climate.

It is, of course, an interesting problem to decide at what stage in the history of other parts of the world these events in South Africa took place, and the comparison of the Uitenhage fossils, of which lists have been given on a previous page, with those found elsewhere afford a means of doing so, although more evidence will be required before the question can be satisfactorily answered.

The plants have recently been examined by Mr. Seward,[1] who came to the conclusion that they are related to both Jurassic and Wealden (Lower Cretace-

[1] Seward (03), pp. 1-46.

ous) plants of other countries, but that the relationship as a whole was closer to the Wealden than the Jurassic flora.

Mr. F. L. Kitchin, who has worked at fossils from allied rocks of India, and who is making an examination of the Sunday's River fossils, has kindly given me the following note upon the question of the relationship of the Uitenhage molluscan fauna .—

"The marine fauna of the Uitenhage series bears abundant evidences of its Cretaceous affinities, and the view, formerly held by some writers, that either a whole or a part of the marine beds is to be brought into parallel with the Oolitic rocks of Europe,[1] can no longer be upheld. Sufficiently conclusive is the occurrence of *Hamites*, *Baculites*, *Crioceras*, *Olcostephani* of the division *Astieria*, *Trigoniæ* of the section Scabræ, *Ptychomya* and other bivalve genera which made their first appearance in Lower Cretaceous rocks. Indeed, it is only possible to follow Neumayr and others[2] in maintaining that this fauna is of Neocomian age, although owing to lack of detailed agreement with the faunas of similar age in Europe, a narrower correlation cannot with certainty be established.

"The occurrence of *Olcostephanus* (*Astieria*) *atherstonei* and close allies in the Valenginian and Hauterivian of Europe may perhaps give the best indication of the position occupied by these marine beds.

"While the cephalopods of the Uitenhage series supply connecting links to the fauna of the Neocomian with which we are familiar in Europe, certain conspicuous forms amongst the bivalves appear, on the other hand, to

[1] Bain (56); Tate (67). [2] Neumayr (82). See also Krauss (47).

possess no close European allies, but serve to connect the Uitenhage fauna in unmistakable manner with that of the marine beds of the Oomia group in Cutch. Peculiar forms of *Trigonia*, in particular, play an important rôle in both cases, lending a similar aspect to the faunas developed in these geographically remote regions, at the same time helping to bring these molluscan faunas into marked contrast with that of the European Neocomian. The characteristic Uitenhage form, *Trigonia ventricosa*, occurs abundantly in the Oomia beds, and is recorded from strata of like age near Coconada on the east side of the Indian peninsula and also in the extra-peninsular district of Hazara.

"On the African continent itself, the only deposits of Neocomian age which may be safely correlated with the Uitenhage beds occur in German East Africa, not distantly remote from the coast-line. Although the cephalopods fail us as a basis of comparison, the occurrence of *Trigonia ventricosa* and some other bivalve forms seems to constitute sufficient grounds for the correlation; the same beds in German East Africa, it is interesting to note, also furnish evidence of their connection with the Oomia group in Cutch by the presence of a species of *Trigonia* which has not yet been found in South Africa.

"The fauna of the Belgrano beds in Patagonia may also be considered to display affinities to that of the marine Uitenhage strata, more especially by the occurrence of *Trigonia subventricosa*, Stanton, which closely resembles the larger form of *Trigonia ventricosa*, and *Trigonia heterosculpta*, Stanton, which is with little doubt allied to the South African *Trigonia vau*."

It thus appears that both the flora and fauna of the Uitenhage beds have distinctly Neocomian characters.

THE CRETACEOUS ROCKS OF PONDOLAND.

On the coast of Pondoland the Cretaceous rocks occur in two narrow strips faulted down against the Table Mountain series that forms the greater part of the coastal district.

The Umzamba Group.[1]

The larger and more interesting of the two, the Umzamba group, lies near the Natal boundary, stretching from a point about three miles south-west of the Umtamvuna River, which is the limit between the two Colonies, to near the Umtentu River, a distance of some twelve miles. The greatest width of the strip is not more than about 700 yards, for the Table Mountain sandstone crops out in the grass-covered ground at that distance from the shore along part of the coast, elsewhere it approaches the beach more closely and at each end of the Cretaceous outcrops appears on the shore itself. The actual contact of the Umzamba beds with the Table Mountain series has not been observed; it is everywhere hidden by the sand that forms dunes behind the beach and often covers up the Cretaceous rocks. The Umzamba beds lie horizontally, and even where their outcrops are very close to the nearest outcrop of Table Mountain sandstone, as on the right bank of the Umzamba River about 300 yards from the mouth, they are of the same nature as on the shore,

[1] Baily and Garden (55), and Griesbach (71).

and do not show any tendency to become conglomeratic, as would be expected if the junction were an ordinary one of a beach deposit with a shore. The Table Mountain series forms rather high ground close behind the Umzamba beds, rising some 300 feet above them within a short distance. It is very probable that the junction is a faulted one, like the junction of the Embotyi beds farther to the south-east.

The Umzamba beds form a line of low cliffs (see Plate XVIII.) extending about a mile north-eastwards from the sand-spit on the left bank of the Umzamba mouth, and they are also exposed at low tide on the shore between the levels of high and low water, where, however, they are frequently more or less concealed by sand. Between the Umzamba and Umtentu Rivers they are exposed between tide marks only, and do not crop out at the back of the beach below the sand dunes.

The rocks chiefly consist of shelly limestones and hard sandy clays containing much carbonate of lime. These two kinds of rock are interbedded; the shelly limestones are thinner than the clayey beds, and at the same time offer more resistance to the weather and the sea, so that on the low cliffs they appear as projecting shelves or ledges separated by the softer beds. The latter have been deeply worn away by the sea, thus giving rise to lines of caves, whose floors and roofs are the hard shelly limestones. The native name of the cliffs to the north-east of the Umzamba mouth is Izinhluzabalungu, "houses of the white men," perhaps in reference to the use of the larger caves by a shipwrecked crew.

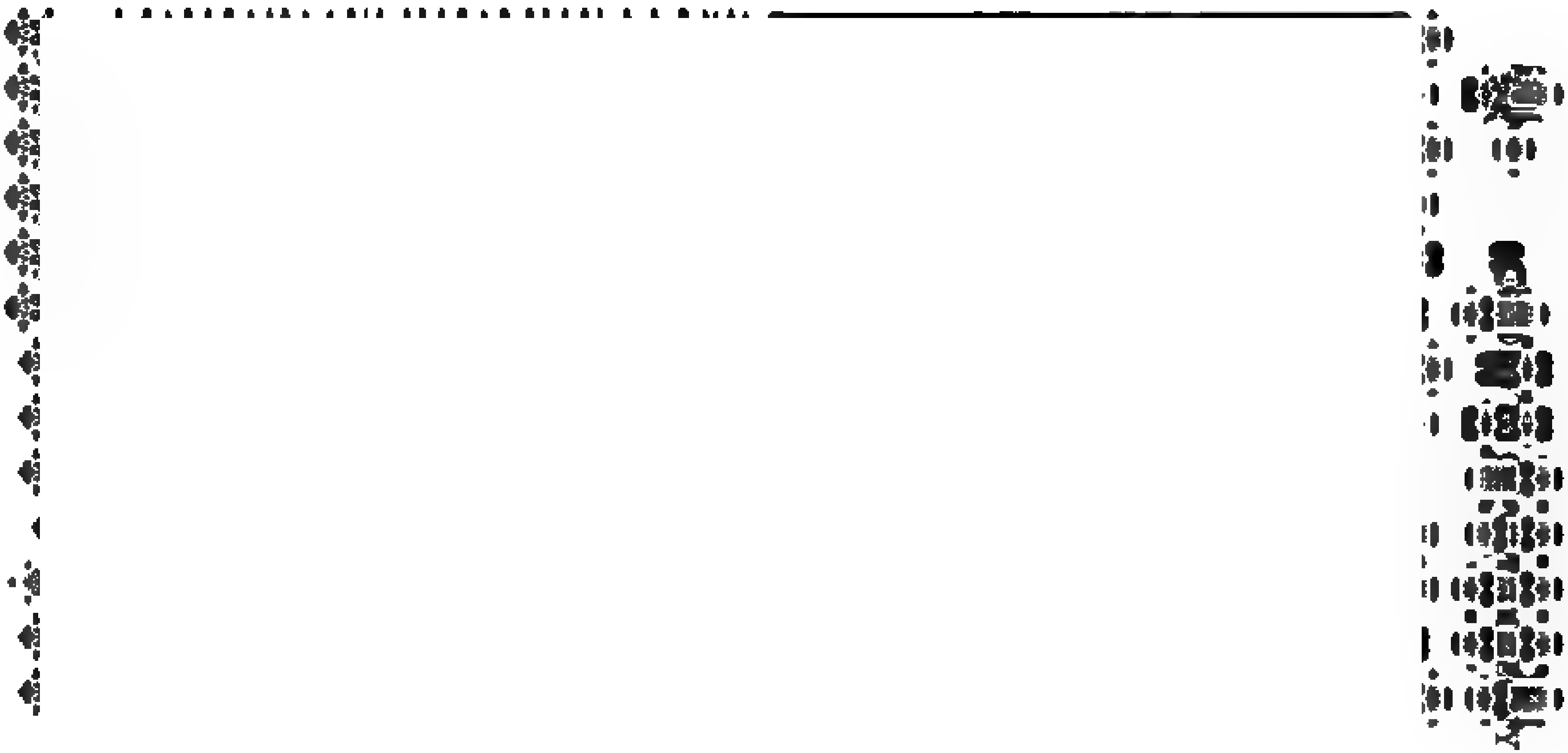


PLATE XVIII.—Cretaceous limestones on the coast about $\frac{3}{4}$ mile N.E. of the Umzamba mouth, Pondoland.

The shelly limestones are made up of fragments and perfect specimens of many kinds of shells, mixed with a comparatively small quantity of quartz sand. They may well be compared to the coarse shell sand found upon many parts of the modern South African shore, with the important point of difference that the shells found in them are of quite different kinds from those found on the present beach. Each bed of shelly limestone can be followed for a certain distance along the cliff, then it thins out, and another similar bed at a slightly higher or lower level takes its place.

The sandy calcareous clays are blue in colour on fresh unweathered surfaces, and they are so tough that the fossils contained in them are only with difficulty extracted from the rock, but the outer inch or two of the exposed outcrops are altered to a soft brown clay, from which the fossils are easily obtained by scraping away the decomposed rock with a knife.

The following section measured on the low cliff near the Umzamba mouth illustrates the nature of the succession in these rocks :—

		Ft.	In.
13	Shelly limestone	0	10
12	Tough sandy clay weathering brown	1	4
11	Shelly limestone	0	6
10	Tough sandy clay	1	0
9	Shelly limestone	0	4
8	Tough sandy clay	3	6
7	Shelly limestone	0	10
6	Tough sandy clay	3	0
5	Black impure limestone with many shells	0	6
4	Black shale	1	0
3	Oyster bed	0	2
2	Fine gravelly conglomerate	0	3
1	(At base) Conglomerate with pebbles imbedded in broken shells ; many fossils		?
		13	3

The coarse bed at the base of the section is exposed on the shore at low water on both sides of the mouth of the Umzamba, but the extent of the rock laid bare at low tide varies, much of it being at times buried under the sand thrown upon the beach by the waves. A strong spring tide will uncover a wide area of rock that is usually concealed. This bed contains many interesting fossils. Reptiles are represented by Chelonian bones of large size; the characteristic bony plates of the shell or shield and the shoulder girdle are easily recognised; another reptile is represented by large jawbones with pointed teeth. Sharks' teeth are rather abundant, and complete the list of vertebrate fossils. The remains of marine invertebrates are plentifully preserved in this bed, the Cephalopods are represented by at least five species of *Ammonites*, a *Nautilus* and a *Baculites;* Gasteropods by *Fasciolaria, Avellana, Chemnitzia* and a large thick-shelled species of one of the Strombidæ; Lamellibranchs by three species of *Pecten, Pectunculus africanus, Protocardium hillanum, Trigonia elegans, Arca natalensis, Cardium denticulatum* and *Inoceramus.* In this lowest bed there are many logs of wood, blackened and partly silicified and often bored into by *Teredo,* whose shells are still at the end of the holes made by their former inhabitants. Many of these fossils are much water-worn, and their surfaces are in consequence abraded. The more delicate shells are rarely or never found in a perfect condition, and a considerable part of the rock is made up of fragments of various kinds of shells. These facts, together with the presence of pebbles of grits, sandstones and dark-coloured slates, undoubtedly point

to the bed having been formed in shallow water, at the bottom of which the pebbles and shells were rolled about until they were covered up by the overlying deposit. The absence of the thin-shelled easily broken fossils, such as *Hemiaster* and *Cassidulus*, two echinoderms that are abundant in the overlying fine-grained beds, leads to the same conclusion.

The shelly limestones also contain the stronger shells in a perfect state; some of the weak shells, such as *Inoceramus*, that break up into small fragments of peculiar shape, can be recognised in these beds, but they are only found complete or nearly so in the fine-grained beds. The shelly limestones seem to have been formed in shallow water, for most of the shells were rolled about, broken, and had the projecting points rubbed off their outer surfaces before they came to rest and were buried under the accumulating sediments.

The fine-grained sandy calcareous clays contain strong and delicate shells in an excellent state of preservation. These beds were laid down in quieter water than the shelly limestones, and in consequence the most delicate shells were buried under the sand and mud without being broken. Over thirty species of Foraminifera and Ostracods have been found by Mr. Chapman in some small lumps of the rock that were sent to him for examination.

The lowest bed in the section given on a previous page is the most persistent of the whole series. The rest of the rocks are separated into many beds by the thin lenticular shelly limestones in such a way that two sections measured about a hundred yards apart would not show precisely the same arrangement of beds.

[illegible]NY

6

[illegible] beds.

[illegible]um denticulatum.
[illegible]bachia umbulazi.
[illegible]aster forbesi.

[illegible]ical Survey of Cape Colony.

This group of rocks was formed near the shore of a sea teeming with life; the shelly limestones were deposited where strong currents prevailed, for a certain period, over a comparatively small area, which were replaced by quiet water that allowed the fine-grained sandy mud to accumulate. The whole thickness of rock at present exposed is but some thirty feet, and it exhibits this alternation of fine and coarse sediments throughout. The same species of mollusca appear to be distributed through the whole group, but their presence in any one layer depends upon whether they were strong enough to resist the destructive action of the sea during the formation of that bed, for the coarse sediments contain the strong-shelled species only in recognisable condition, while the fine-grained beds contain both the thick and thin shelled species.

The following is a list of the chief species of invertebrate fossils from the Umzamba beds:—

Cephalopods—
Anisoceras rugatum, Forbes.
Baculites sulcatus, Baily.
Lytoceras (*Gaudryceras*) *kayei*, Forbes, sp.
,, (*Pseudophyllites*) *indra*, Forbes, sp.
Puzosia (*Hauericeras*) *gardeni*, Baily, sp.
,, (*Hauericeras*) *rembda*, Forbes, sp.
Schlœnbachia soutoni, Baily, sp.
,, *stangeri*, Baily, sp.
,, (*Prionocyclus*) *umbulazi*, Baily, sp.

Gasteropods—
Avellana ampla, Stol.
Cerithium detectum, Stol.
,, *kaffrarium*, Griesb.
Euchrysalis gigantea, Stol.
Fasciolaria assimilis, Stol.
,, *rigida*, Baily, sp.

Gasteropods—*continued*—
Natica multistriata, Baily.
Pollia pondicherriensis, Forbes, sp.
Pugnellus uncatus, Forbes, sp.
Scala turbinata, Forbes, sp.
Solarium pulchellum, Baily.
,, *wiebeli*, Griesb.
Tritonidea trichinipolitensis, Forbes, sp.
Turbonilla ? undosa, Forbes, sp.
Turritella multistriata, Reuss.
Dentalium, sp.

Lamellibranchs—
Arca capensis, Griesb.
,, *umzambaniensis*, Baily.
Astarte, sp.
Cardium denticulatum, Baily.
Corbula, sp.
Cytherea arcotensis, Forbes, sp.
Cucullæa natalensis, Baily, sp.
Inoceramus expansus, Baily.
Neithia quinquecostata, J. Sow., sp.
Nucula, sp.
Ostrea, sp.
Pecten amapondensis, Griesb.
Pectunculus africanus, Griesb.
Protocardium hillanum, J. Sow., sp.
Trigonia elegans, Baily.
,, *shepstonei*, Griesb.
Teredo, sp.

Echinoderms—
Hemiaster forbesi, Baily.
Holaster indicus, Forbes.
Cassidulus, sp.

Mr. F. L. Kitchin, who has in hand the examination of the invertebrate fossils collected from these beds by the Cape Geological Survey, has kindly furnished me with the following note upon the relationship of the fauna to that of certain beds in India and other countries.

"The palæontological relations of this limited series of Cretaceous strata are comparatively easy of solution. When it is realised that a very restricted time-range is represented, and that there is no evidence of a succession of contrasted faunas, as was formerly believed to be the case, it becomes clear that we are only dealing with a true representative of the Arialoor (Upper Senonian) stage, so well known from its development in the Trichinopoli and Pondicherri districts of Southern India. Relationship to the Cretaceous rocks of Southern India was first indicated by Baily, more clearly emphasised by Griesbach, and more recently again by Kossmat, whose writings have thrown such light on the dispersion of the cephalopods of this age and the significance of the evidence yielded by these rocks in South Africa and Southern India. Amongst the more important species connecting this Cretaceous fauna of Pondoland with the Indian Arialoor stage are *Puzosia gardeni*, *Puzosia rembda*, *Lytoceras kayei*, *Lytoceras indra*, *Anisoceras rugatum*, *Pugnellus uncatus*, *Pollia pondicherriensis*, etc. Other deposits of Arialoor character in the Pacific region with which these beds in Pondoland show strong palæontological relations, are developed in Japan, Vancouver Island (and California), and Quiriquina Island (Chili). The intermingling of essentially Pacific types with other forms having stronger European affinities (*e.g.*, species of *Schlœnbachia*) led Kossmat to regard these Cretaceous beds of Pondoland as of special importance in indicating the line of dispersal between the North Atlantic and the Indo-Pacific regions during Upper Senonian times."

The Embotyi Group.

Near the mouth of the Embotyi River, about seventeen miles north-east of St. John's, there is a group of conglomerates and green sandstones stretching about four miles south-west from Waterfall Bluff. At the south-western end of the outcrops the beds lie nearly horizontally, and behind them are shales and sandstones probably belonging to the Ecca series, which have a rather high dip to the south-east. The junction of the two groups has not been seen, but it is very probably an unconformity. Farther to the north-east the Embotyi beds dip at moderate angles to the north-east, north and south, showing that they have been considerably disturbed since their deposition. At the north-eastern end of the exposures the Embotyi beds rest against a cliff of Table Mountain sandstone, and the slickensides still visible on part of the cliff, together with other evidence in the conglomerate itself, prove that the Embotyi beds have been faulted down against the older rock. The line of fault runs westwards from Waterfall Bluff, and about two miles from the latter separates the Table Mountain sandstone from the Ecca beds. Waterfall Bluff is a vertical cliff, some 300 ft. high, whose base is washed by the sea; the streams from the country behind the cliff fall over it, hence its name. The westward prolongation of the line of cliffs coincides with the foot of the escarpment on which the Egossa Forest stands.

The finer-grained portions of the beds, which appear on the shore near the mouth of the Umgwegwane River, are green shales and sandstones containing fragments of blackened wood, the only organic remains hitherto found

in the group. Further search in these rocks is likely to be rewarded by the discovery of plant remains that cannot fail to be of great interest, and it is to be hoped that the search will be made before long.

The conglomerates towards the south-west end of the outcrops are pebbly rocks with water-worn fragments of dark grits and mudstones, certainly derived from the underlying Karroo beds. North-east of the Umgwegwane River the conglomerate becomes extremely coarse, and bedding planes are often difficult to find. Near the conical green hill on the Waterfall Bluff side of the river, and between that hill and the Bluff, immense blocks of coarse and fine-grained dolerites are found interbedded in a matrix of smaller boulders of similar material and of dark grits, mudstones and shales like those in the conglomerate farther south-west. Some of the dolerite blocks measure twenty feet in length. This conglomerate is the most tumultuous looking rock in the Colony; magnificent exposures of it can be seen on the seaward face of the green hill, and near Waterfall Bluff. The irregular spaces between the boulders are sometimes filled with radiating bunches of brown calcite. The fine-grained portion of the rock is greenish and very similar to the sandstones near the Umgwegwane mouth.

The occurrence of the dolerite boulders in the Embotyi rock is of great interest, as it proves that the dolerites had been injected into the Karroo formation before the deposition of the conglomerates, and were exposed at the surface during their accumulation. The similarity in situation of the Embotyi group to that of the Umzamba beds, which crop out at a distance of some

twenty-four miles to the north-east, and the fact that they are both faulted down against the Table Mountain sandstone, thus belonging to an earlier age than the chief disturbances that have affected this part of the Colony since the close of the Karroo period, make it probable that the Embotyi group belong to the same series as the Umzamba beds. They may be regarded as the basal portion of the Pondoland Cretaceous rocks, and as bearing the same relation to the marine Umzamba beds as the Enon type of the Uitenhage series does to the Sunday's River beds.

There is nothing to be said concerning the economic value of the Pondoland Cretaceous series. The Umzamba beds make a very pretty bit of coast with its line of cliffs hollowed out into numbers of caves overhung by *Strelitzia* and other plants that are only found in the eastern parts of the Colony. The Embotyi beds occur in what is perhaps the most beautiful place in the Colony. The Egossa Forest forms a fine background, rising some 1,200 feet above the sea; below it are low hills covered with tall grass and large bushes and trees, and between the hills wind the Embotyi, Umgwegwane, and another river, widening out into broad lagoons just before they reach the sea. The writer was on that shore one afternoon when a thunderstorm passed over the forest, while the sun still lighted up the white breakers of the Indian Ocean and not a breath of wind disturbed the lagoons, from which were reflected the subtropical trees and bush growing on their banks. The scene was certainly the most beautiful one it has ever been his fortune to look upon.

CHAPTER IX.

VOLCANIC PIPES YOUNGER THAN THE STORMBERG VOLCANOES.

In many parts of the Colony there are remarkable pipes, channels through which materials were thrown from the lower region of the earth's crust to the exterior, and now filled with substances of different kinds, sometimes clearly of volcanic nature, but often of such peculiar character that their volcanic origin is not obvious and can only be surmised from the manner in which the rocks occur.

The first of these pipes to be discovered was the Jager's Fontein Mine, in 1870, but those at Du Toit's Pan, Bult Fontein, Colesberg Kopje (Kimberley Mine), and De Beers were found soon afterwards.[1] These discoveries were entirely due to the finding of diamonds, which had been met with by chance near the Orange River three years previously. It was, of course, some time after the diamond mines were opened that their nature was understood.[2] The earliest search for diamonds was carried on in the alluvial deposits or "River diggings" on the Orange and Vaal Rivers; the later or "Dry diggings" in the volcanic pipes, which

[1] For an interesting and fully illustrated account of the early discoveries and of the whole history of the diamond mines and their working see *The Diamond Mines of South Africa* by Mr. Gardner F. Williams, 1902.

[2] Cohen (72), pp. 857-62. This paper, or letter, contains the first suggestion of the volcanic nature of the pipes.

have been the source of so great an industry in South Africa, followed upon the discoveries mentioned above.

Several other pipes are known in West Griqualand, but not much detailed information about them is available. South of the Orange River two vents near Hanover are marked on Mr. Dunn's map (3rd edition, 1887), and four near Fraserburg; others exist near Carnarvon,[1] but no accounts of most of these have been published. Lately nearly thirty vents have been mapped in the Sutherland Division. One other, the neck on the farm Spiegel River in Riversdale, is known; in some respects this one is of very great interest, as it affords more evidence of the later origin of the whole class of vents than is obtainable farther north, and it is at one end of the group in a petrological sense as it is filled with an igneous rock resembling a well-known but scarce variety of dyke-rock in foreign countries and in East Central Africa. The Saltpetre Kop (Sutherland) vents stand at the other end of the petrological series in being almost entirely filled with fragments of sedimentary rocks.

There are many intermediate conditions between the two extreme types to be found amongst the comparatively few vents that have hitherto been examined from a geological point of view, and when a fuller series is known every gradation will doubtless be recognised.

We shall commence the description of the pipes with an account of those filled with rocks of the purely igneous type and proceed in the order of their departure from this type without regard to their geographical

[1] Dunn, *Geological Sketch Map of Cape Colony* (73); (74) pp. 54-60.

positions. At the end of the description the reasons for considering the whole group as belonging to one period of volcanic activity will be given together with other points of general interest.

On the farm Spiegel River in the Riversdale Division there is a most remarkable mass of melilite-basalt exposed at the top of a hill composed of conglomerates and sandy beds belonging to the Uitenhage series. The outcrop is about 300 feet in diameter from east to west and rather less in the other direction, but the exact junction with the surrounding rock is difficult to find on account of the debris covering the slopes on which it should be exposed. The grey-black igneous rock is in places roughly columnar, but the columns are very feebly developed; they slant towards the east. The only feasible explanation of the occurrence is that the melilite-basalt fills a volcanic neck. The want of good exposures and the crumbly nature of the conglomerates prevent the observation of the dip of these beds at the contact. The beds are seen at several places within 200-300 yards of the vent but they present no points of difference from their nature at a greater distance from the spot. No other neck or intrusion has yet been found in the Uitenhage beds, and till lately no other occurrence of melilite-basalt had been observed in South Africa.[1] The rock is composed of

[1] The peculiar rock described by Cohen (Tschermak's *Min. u Petr. Mitth.*, Bd. xiv., Heft 2) as a melilite-augite rock is quite different from any of the rocks mentioned in this chapter. It is composed of melilite and augite, without any olivine, perofskite or iron ores, and contains native copper. It came from the Zoutpansberg District, Transvaal. It has been regarded as a rock altered by use in the hearth of a furnace.

a ground mass of glass in which there are minute crystals of perofskite and magnetite, irregular grains of augite, immense numbers of melilite crystals showing the usual characters of that mineral, and fairly large well-formed crystals of olivine. It is in a remarkably fresh state for so basic a rock.[1]

The vents and semicircular dyke on the Commonage near Sutherland village are mostly filled with rocks of a thoroughly igneous character; tuffs, or rocks made up of small fragments of various kinds, including lava and minerals derived from it, are found in three or four of the seven necks, but with them are the igneous rocks; in the case of three of the pipes the igneous rock is melilite-basalt with more glass and biotite and less augite and melilite than the Spiegel River rock contains; serpentine, calcite and zeolites, the products of alteration of the other constituents are abundant.[2] The curved dyke is composed of a similar rock. The tuffs in the vents in which the melilite-basalt occurs are light blue sandy rocks containing biotite, ilmenite, serpentine and perofskite in addition to the debris derived from sedimentary beds. The other vents on the Commonage are filled with a dark-coloured amygdaloidal basic glass, and in some cases blocks of sandstone and shale with smaller fragments of the same rocks are imbedded in a matrix evidently composed mainly of altered glass of the nature of the glassy lava in these vents. Serpentine pseudomorphs after olivine are the only large crystalline

[1] An analysis by Mr. Lewis, one of the Cape Government analysts, is given in *Geol. Comm.* (03).

[2] Description of these rocks will be found in *Geol. Comm.* (03).

constituents of this lava, and they appear to have come from another rock, a fine-grained highly altered material which still adheres to the serpentine pseudomorphs; augite and magnetite are the other constituents that have been recognised, and they are in very minute grains and crystals. The steam holes in this lava are filled with calcite, analcite, natrolite and other zeolites, but silica, which in the form of quartz or chalcedony is frequently found in the steam holes of the ancient Zeekoe Baard lavas and those of the Stormberg series, has not been found in the Sutherland Commonage amygdaloids.

At Matjes Fontein, a farm nine miles south-east of Sutherland, there is a pipe partially filled with melilite-basalt of rather peculiar characters[1] and partly with a gritty breccia containing large fragments of granite, dolerite of the Karroo type, quartzite and other sedimentary rocks, mica, ilmenite and hornblende. The three latter constituents are identical in nature with the same minerals in the Silver Dam pipe to be mentioned presently. The melilite-basalt of this outcrop is composed of olivine, melilite, perofskite, biotite, magnetite, calcite and serpentinous fibres, probably derived from a glassy ground mass. Excepting the presence of calcite and the serpentine fibres the rock is remarkably fresh, and differs in several respects from the other melilite-basalts. It shows a marked flow-structure.

In the remaining pipes there is no large body of igneous rock corresponding to the melilite-basalts and

[1] See *Geol. Comm.* (03) and Rogers and Du Toit (04).

[illegible] in the sense [illegible] It is worthy [illegible] *…roxenes* are absent [illegible] altered to serpen- [illegible] the matrix of the [illegible] ar have a resem- [illegible] he blue-ground of [illegible] to the north of [illegible] ch occur in these

heavy basic rocks are also the most conspicuous fragments in the breccia, and there is no doubt that they were derived from the same source that the boulders came from. The less conspicuous constituents of the breccia, only determinable under the microscope, are perofskite, serpentine pseudomorphs after olivine, grains of quartz and argillaceous matter derived from sedimentary rocks and calcite. The harder variety of breccia contains less serpentine and more sand and clay than the softer, but all the minerals mentioned above occur in both kinds.

Saltpetre Kop is a very prominent hill in the Sutherland Division rising about 1,000 feet above the general level of the high plateau on which it stands. It is composed of breccia and tuff, filling a vent about 1,000 yards long by 600 wide; the vent traverses the Beaufort beds which are turned upwards for a considerable distance on all sides; the dip of the Beaufort beds is extremely slight in the surrounding district, but at points about a mile and a quarter from the neck the strata have a distinct dip away from it and the inclination increases as the neck is approached, so that near the breccia the beds are nearly vertical.[1] Round about this large neck are nineteen others of smaller size and forty-six dykes, mostly filled with fine tuffs or breccias. In the case of one dyke the rock has been found to be largely composed of one of the less basic plagioclase felspars, and is evidently an igneous rock of somewhat peculiar character, but it has been greatly altered by the

[1] A fuller description and plans of the Saltpetre Kop area will be found in *Geol. Comm.* (03) and Rogers and Du Toit (04).

substitution of calcite, hydrated ferric oxides, and silica for some of its original components. The breccias and tuffs vary greatly, but they all consist mainly of fragments of sedimentary rocks set in a matrix of similar substances finely comminuted; but in addition to these constituents there are pieces of granite, gneiss, mica schist and Karroo dolerite, and also mica, hornblende and ilmenite, identical in character with the similar minerals in the Silver Dam breccia. Parts of the breccias and tuffs are strongly impregnated with carbonates of lime and magnesia, barium sulphate, hydrated oxides of iron and silica. This has happened chiefly in the smaller pipes and in the peripheral portion of the large vent; a similar process has caused the hardening of the shales and sandstones at their contact with the vents and dykes. The carbonates, sulphates, oxides of iron and silica were probably carried to their present position by water ascending the channels of eruption after the period of violent activity had closed; their deposition may be regarded as analogous to the effects of the "solfataric" stage of recent volcanic areas.

The smaller necks in the Saltpetre Kop area do not materially affect the regularity of the quâ-quâ-versal dip about the central vent.

In no other vent of the kind we are dealing with in this chapter is the outward dip or up-turning of the surrounding strata so strongly marked as in the case of the central neck of the Saltpetre Kop group. Wherever the strata in immediate contact with one of the pipes are exposed, and have been examined with attention, they have been found to dip away from the contact, as

though the ascent of the materials filling the pipes had bent the edges of the strata upwards. This has been noted at some of the Sutherland Commonage vents, at Balmoral (Ratel Fontein), at Matjes Fontein, Schiet Fontein and at Kimberley. This feature seems to be peculiar to these vents, for where notice has been taken of the dip of the strata near the pipes of volcanoes of the more usual types the strata have been found to be inclined towards the pipe as though dragged downwards by the settling in of the contents after the activity of the volcanoes ceased.[1]

On the farms De Vrede, Portugal's River, and Blaauw Blommetjes Keep, in the Sutherland Division there are breccia-filled pipes and dykes. The Blaauw Blommetjes Keep pipe gives off a sheet-like extension of the breccia, which distinctly traverses a thick sheet of dolerite, and thereby proves that the production of the vent was posterior to the consolidation of the dolerite, a strong confirmation of the evidence afforded by the fragments of coarsely crystalline dolerite found in the breccias of many of the necks of this class.

At Balmoral (Ratel Fontein), in the Fraserburg Division, there is a circular depression in the ground about 300 feet wide and ten to twenty feet deep, surrounded by the truncated edges of the Beaufort beds dipping away from the depression. The depression is caused by the weathering away of a soft breccia which fills a pipe.

[1] It is naturally only in long extinct volcanoes that observations on the dip of the sedimentary strata, below the pile of the volcanic debris forming the cone or mountain, can be made. Several sections through such strata are given in Sir A. Geikie's *Ancient Volcanoes of Great Britain.*

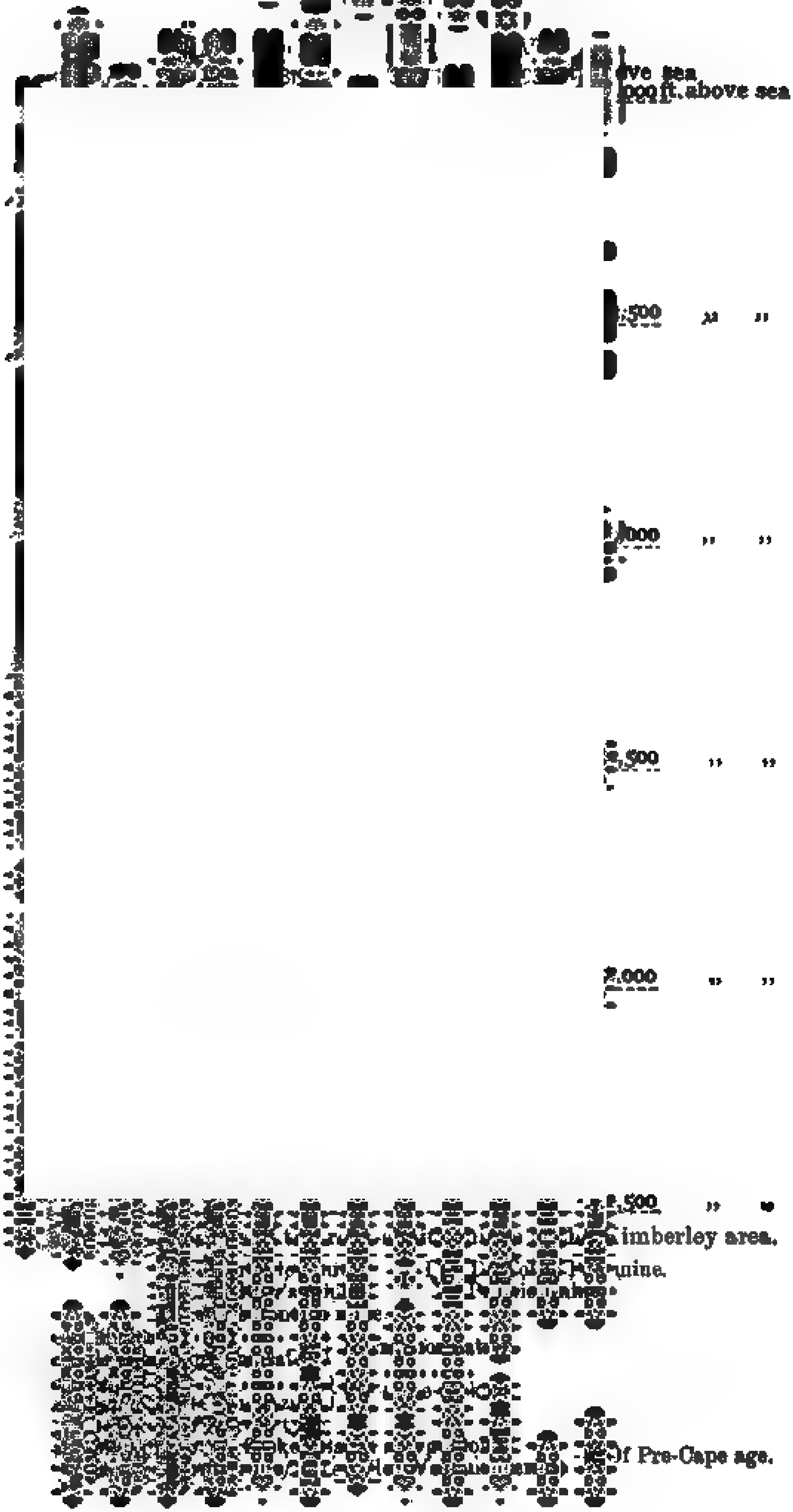
The breccia is a blue muddy rock containing fragments of sandstone and shale, dolerite, biotite, garnet and ilmenite. This pipe is remarkably well exposed, and the nature of the contact and the up-turning of the edges of the sedimentary rocks through which the pipe passes can be more satisfactorily seen than at any other locality yet described.

At Schiet Fontein and other farms near Carnarvon and near Hanover similar pipes are known; they have been briefly described by Mr. Dunn[1] but no details have yet been published concerning them.

To the north of the Orange River, in the Cape Colony, the Orange River Colony, and the Transvaal, there are many of these volcanic pipes. Several of them, including those at Kimberley, are surrounded at the surface by rocks belonging to the lower stages of Karroo formation, but farther to the north and west, where these strata have been removed by denudation, the pipes crop out through the Pre-Cape rocks. At Kimberley the mines are being worked far below the base of the Karroo formation, as the accompanying sections[2] show. The quartzites, amygdaloidal rocks ("melaphyres") and quartz-porphyries passed through by the rock shafts, from which access to the mine (the pipe filled with blue-ground) is gained by horizontal tunnels, belong to the Pre-Cape formations; but the dolerite, or diabase as it is usually called by French and German writers, is part of the great intrusions of late Karroo age described in chapter vii.

[1] Dunn (74), pp. 54-60.

[2] I am indebted to Mr. Gardner F. Williams for these sections.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The "blue-ground" or kimberlite (Carvill Lewis) which fills these pipes is a serpentinous breccia containing many kinds of minerals. The chief varieties are olivine or serpentine pseudomorphs after that mineral, biotite, chrome-diopside, enstatite, smaragdite, garnet, perofskite, magnetite, ilmenite, chromite, picotite, apatite, epidote, orthite, tremolite, tourmaline, rutile, and diamond. Calcite, various zeolites, chalcedony, and talc are also present, but they must be looked upon as having been introduced after the volcanic activity ceased, or as alteration products of the other constituents. It is impossible to be certain which constituents are part of the blue-ground as distinguished from the fragments contained in it, but there is reason to regard the olivine, magnetite, ilmenite, and perofskite as belonging to a formerly molten magma which carried up with it, during the explosion that established the pipes, part of the olivine, the pyroxenes, garnet, smaragdite, diamond and several other minerals that were derived from deep-seated rocks other than the then molten lava. This view was strongly supported by Professor Bonney,[1] who gives convincing evidence in favour of it as regards diamond and other constituents of an eclogite from the Newlands Mine. Descriptions of the Newlands Mine show that the blue-ground occurs in an irregularly shaped pipe and as dykes and sheet-like extensions in the surrounding rocks.[2] At the De Beers Mine a hard variety of blue-ground, called snake-rock, which occurs in the form of a dyke in the softer blue, extends as a dyke through

[1] *Geol. Mag.* (99), pp 309-21.
[2] Graichen (03).

the country rock outside the pipe itself, just as at Saltpetre Kop, Blaauw Blommetjes Keep, and De Vrede the breccias form dykes in the Beaufort beds. The shape of the pipes appears to vary at different depths, but on this and many other points of great interest concerning the occurrence of the breccias no complete or detailed information is yet available. The composition of the breccias is by no means constant in the different mines or in one and the same pipe. A striking instance of this fact is the abundance of enstatite in the rocks from De Beers Mine described by the earlier writers, while in many specimens from deeper levels it is certainly a rare constituent.

In some of the pipes in the Kimberley area large masses of sedimentary rocks have been found embedded in the blue-ground; some of these contain fossils. The sandstone fragments with *Atherstonia*, a fish, have probably come from the Beaufort beds, and some reptilian remains which have been found in the Premier Mine may have had a similar origin. These fragments probably dropped into the pipes from the wall at a higher level than that at which they were found. The large logs of charred wood sometimes met with in the blue-ground may have fallen into the vents from the surface after the explosions had taken place. Had the logs been fossilised wood derived from the Karroo strata we should expect to find them in the same strata as the fossil wood in those beds, *viz.*, in the form of silicified wood, in which silica replaces the woody tissue and fills the cells.

There have been many views held as to the real

nature of the blue-ground,[1] but the best supported is certainly that in which it is regarded as a breccia derived from an igneous rock of ultra-basic composition. The late Professor Carvill Lewis[2] considered that the "abundance of calcite as a decomposition product, the high magnesia and low alkali, the presence of biotite, and more especially of perofskite," indicate the former presence of nepheline or melilite, and that the rock may have been a melilite-basalt. The discovery of melilite-basalt in similar pipes in Sutherland is certainly striking in view of this opinion. The same author considered the blue-ground to be a true igneous lava, and not a mud or ash, but this view is difficult to reconcile with many of the facts, as the editor of his papers points out. It seems more justifiable to regard the contents of the Kimberley pipes as breccias derived from the explosive disintegration of a body of lava of ultra-basic composition; another effect of the explosion was to break up masses of rock (which may be called eclogite), composed of pyroxenes, olivine, ilmenite, biotite and garnets, to mention the more abundant minerals only, and to throw the minerals thus obtained up the channels opened by the explosion, mingled with the lava in a solid or plastic state. Whether the eclogites were originally altogether distinct from the molten lava, or whether they were an

[1] A general summary of these views will be found in chap. xvi. of Mr. Gardner Williams' book, cited on a previous page.

[2] *The Genesis and Matrix of the Diamond*, edited after the death of the author by Professor T. G. Bonney, London, 1897. This contains the best account of the rocks and minerals of the Kimberley pipes in the English language. For other references see under Bonney, De Launay, Story-Maskelyne and Flight, Lacroix and Cohen in the appendix.

early product of the same magma is another matter, which is difficult to decide with the help of the evidence at present available. The abundance, however, of perofskite in the blue-ground, and its absence from the eclogites hitherto described from the pipes, seems to indicate separate origins for the two rocks.

Another feature of importance is the occurrence of well-rounded boulders of several of the rocks enclosed by the blue-ground. Professor Bonney described an eclogite boulder from the Newlands Mine, and came to the conclusion that it had been picked up in that form by the blue-ground when the explosions took place. At Saltpetre Kop and other vents in Sutherland, similarly shaped boulders of hard quartzite, eclogite and granite occur. At Balmoral a garnet rock and dolerite of the Karroo type are found in this form. The dolerite boulders could hardly have been obtained in that shape from a conglomerate, as there are no known conglomerates, containing dolerite boulders, of earlier age than the pipes. It is possible that the quartzite boulders of the Saltpetre Kop agglomerates were derived from the Dwyka conglomerate, but a similar explanation cannot be held to account for the eclogites. These rocks have not been observed in the Dwyka conglomerate, and their extraordinary abundance in the Silver Dam breccia, as well as in some of the northern pipes, is inconsistent with the paucity of boulders of granite and certain other rocks in the breccias, for those rocks are very frequently seen in the Dwyka conglomerate. In addition to this, the eclogites, or minerals derived from them, are quite as characteristic of the breccias from the pipes in

regions where the Dwyka conglomerate is but thinly developed or entirely absent, as in districts where that conglomerate almost certainly underlies the surface.

From the foregoing descriptions of the breccias and other rocks filling the pipes and fissures we see that, though they differ widely, yet there are usually connecting links between them to be noticed. Had the Spiegel River melilite-basalt been the only example of this type of rock known in the Colony it would have been extremely rash to postulate any connection between it and the contents of the long known Kimberley pipes; but the association of the melilite-basalts of Sutherland Commonage and Matjes Fontein in the same pipes with breccias containing some of the characteristic minerals of kimberlite, and their occurrence close to the Silver Dam vent, which is filled with an agglomerate still more like typical kimberlite, render the supposition much less improbable. In the remarkable agglomerates of the Saltpetre Kop group of pipes we find that though the bulk of the rocks are composed of the debris of sedimentary beds, yet there are also numerous fragments of the biotite, ilmenite and hornblende characteristic of the Silver Dam breccia. The occurrence of kimberlite in the form of dykes and sheets, as well as in the pipes, is analogous to the agglomerate dykes and sheet of Saltpetre Kop and Blaauw Blommetjes Keep, though such phenomena are distinctly unusual. It is interesting to notice that similar dykes of a rock apparently indistinguishable from kimberlite have been found at two places in North America, at Syracuse (New York) and

in Kentucky.[1] In the Cape Colony only one other grit or detrital dyke has been found. It is a remarkably regular outcrop of a gritty rock composed of grains of quartz, felspar, garnet, epidote and other minerals, and it extends for a long distance through the Witteberg beds near Elands Vley, west of the Tanqua Karroo. It has a width of about eight feet and is said by the local farmers to be clearly traceable for thirty miles across the country. Its age is unknown, but as it is so unlike any other geological feature in the country it may be mentioned here in connection with the phenomena which bear the nearest analogy to it. The remarkable characters of the contents of certain pipes, such as those of Silver Dam and Balmoral, are closely similar to those of Kimberley, and the fact is sufficient to support the view that these vents were established by similar means, and at about the same time.

The age of each vent can only be determined by observing the strata which it traverses and by finding rocks of known age in the breccias. It is obvious that a vent is younger than the beds passed through, and younger than the rocks contained in it in the form of fragments or boulders. The usual evidence of the date of the extrusion of volcanic rocks is entirely wanting here. The only satisfactory answer to such a question is the interbedding of tuffs or lavas with contemporaneously formed sediments. In the case of the Stormberg volcanic beds, for instance, they have

[1] Descriptions of these rocks and their occurrence and references to the original papers will be found in Professor Bonney's edition of Carvill Lewis's papers.

been found intercalated between the ordinary sediments of the upper division of the Stormberg series, and their age is thereby satisfactorily settled, though we do not know how long the volcanic activity prevailed. In the cases of the Kimberley, Sutherland, Fraserburg and other similar pipes, excluding the Spiegel River neck, we know that they were formed after the intrusion of the Karroo dolerites, for they either pass through sheets of dolerite or contain fragments of that rock evidently torn from sheets or dykes. The dolerite intrusions as we saw in the last chapter, probably belong to the Stormberg period, therefore the pipes were probably produced later than that period. This is as much as can definitely be stated with regard to the age of those vents. If, now, the general resemblance of the Spiegel River melilite-basalt to the somewhat similar rocks of Sutherland be considered as evidence of their close connection in origin, or, in other words, of their belonging to one and the same phase of volcanic activity in the Colony, as in my opinion it may be, then the earlier limit of the age of these pipes is advanced from Post-Stormberg to Uitenhage or Post-Uitenhage times. It is worth while mentioning the fact that the other known African rocks containing melilite and having a distinct, though perhaps not very close, resemblance to the Colonial melilite-basalts occur in East Africa at Doenyo Ngai, Makinga Hill and Mount Elgon.[1] At the present

[1] Short descriptions of these rocks are given in Zirkel (94) and Rosenbusch (96) p. 1,276. G. T. Prior (03) describes the Mount Elgon rocks. The others are described by Mügge (86) and Lenk, but I have not had access to these two papers.

time no great importance can be attached to the resemblance between rocks so far removed from one another, especially as the examples in the Colony show no indications of the surface features consequent on their eruption, while the East African rocks are of quite recent date.

We may sum up this account of these peculiar vents which are distributed widely over South Africa by saying that at some period after the close of Stormberg times (probably after the commencement of the Uitenhage period) great explosions took place which drilled holes of various sizes through great thicknesses of rock, and that although some of these holes were filled with lavas of basic composition, the majority are occupied by agglomerates, breccias or tuffs. These fragmental rocks are composed of material derived from the molten magma which was intimately connected with the immediate cause of the explosions, mingled with other matter torn from deep-seated rocks or from the strata through which the pipes were opened.

The occurrence of diamond as a constituent of some of the breccias has been the cause of a far wider interest in the pipes than would otherwise have been the case. For many years the diamond was thought to have been derived from the crystallisation of the carbon originally contained in the carbonaceous shales surrounding the pipes, but the presence of the mineral in the blue-ground at levels far below the shales, and its occurrence near Pretoria in kimberlite filling a pipe in the Pretoria series, which lies below any known carbonaceous rocks,[1]

[1] Molengraaff (98) p. 123.

finally disposed of that theory. The presence of diamond in the form of good crystals in the garnetiferous eclogites[1] affords strong support for the view that it crystallised out from solution in an ultra-basic rock-magma, which sometimes gave rise to eclogites. Whether any other variety of rock magma enabled the mineral to form remains to be proved. Hitherto eclogite containing diamond has only been found in breccias of the kimberlite type, no outcrops of eclogites or other ultra-basic rocks containing the mineral have yet been found.

[1] Bonney (99) pp. 309-321.

CHAPTER X.

RECENT OR SUPERFICIAL DEPOSITS.

In many parts of the Colony there are accumulations of sand, gravel, alluvium, limestones, quartzites, and ferruginous rocks that belong to a comparatively recent order of things, and in some cases are to-day in process of formation. There is invariably a marked unconformity between those rocks and the strata upon which they rest, although it is not always easy to find a suitable exposure of the junction.

For the purpose of description the superficial deposits may be divided up into the following groups, but they were not so distinct in origin, and, as we shall point out later, some groups grade into others :—

1. Older gravels, alluvial deposits and quartzites.
2. Newer gravels and alluvial deposits.
3. Laterites.
4. Blown sands.
5. Limestones of the coast belt.
6. Limestones of the interior.
7. Raised beaches.
8. Vley and pan deposits.

1. Throughout the folded region and to the west of its western portion there are many signs that the country was to a certain extent reduced to a plain at

a period when the rivers flowed at levels of some 600—1,000 feet above their present beds. In the Ruggens of Caledon, Swellendam, Bredasdorp, and Mossel Bay, a great tract of hilly country carved out of rocks chiefly belonging to the Cape and Uitenhage formations, the hill-tops reach a more or less common level from 800 to 1,200 feet above the sea. The summits are composed of gravels, alluvium, and quartzites of a peculiar nature, and are frequently table-shaped. If one looks over the Ruggens from any prominent point in Swellendam or Riversdale the conviction that these isolated patches were once continuous, and that they formed a gently undulating surface connected with the terrace that is at places a very conspicuous feature along the lower slopes of the Langebergen, is immediately borne in upon one.

The terrace on the mountain-side north of Zuurbraak is separated by the deep valley of the Buffeljagt's River from the gravel-capped plateau south of that place; the gravels are coarse and contain many pebbles and boulders of Table Mountain sandstone that must have come from the Langebergen, although the ground on which they lie is now quite cut off from the mountains by the deep valley. There is no doubt that the terrace and the plateau were once continuous, and that the pebbles were brought from the Langebergen by the mountain streams that now feed the Buffeljagt's River. In this case the rocks underlying the plateau are mainly Bokkeveld slates, but on the west a tongue of the Swellendam basin Uitenhage beds enters into its composition without altering the character of the plateau, in spite of the

fact that the Uitenhage beds are more easily eroded than the Bokkeveld.

To the east of the Gouritz River the road from Herbertsdale to Hagel Kraal lies on a terrace stretching far to the south of the Langebergen, cut out of the Table Mountain, Bokkeveld and Uitenhage beds in different parts. This terrace is considerably cut up by eastern tributaries of the Gouritz River, but it is not divided into a terrace and a plateau as is the case with the old Zuurbraak terrace; the unity of the whole is still preserved. The Nouga River has exposed admirable sections showing the terrace gravels lying unconformably upon the Uitenhage beds, which there have a moderate northerly dip.

To the north of the Langebergen both the terraces and the plateaux are well represented. The former can be seen from the roads to Oudtshoorn from Mossel Bay where they leave the mountains at Saffraan River (Robinson Pass) and Doorn River (Montagu Pass). The best example of a plateau in this district is the Tafel Berg, between the Waterval and Bok Kraal Rivers south of Buffels Fontein, a wide table-shaped area that does not deserve the name of Berg. It is covered with gravels derived from the Langebergen, from which it is now separated by the Waterval River.

In the Oudtshoorn-Uniondale-Willowmore area there is a great development of high level gravels (see Plates XIX. and XX.). The watershed between the Olifant's and Baviaan's Kloof Rivers is on one of them. The present rivers for the most part run in deeply eroded valleys cut down through the plateau gravels. The

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occur along the northern flank of the range at least as far as Prince Albert, where there are also some fine table-shaped and gravel-capped hills lying considerably to the north of the mountains.

In the neighbourhood of Grahamstown the gravel and quartzite terraces south of Botha's Hill and the curious Sugar Loaf Hill nearer the town are parts of a slightly undulating plain that has been cut into by the Blaauw Krantz River. The underlying rocks belong to the Witteberg and Dwyka series.

In the country north-east of the Gualana River, where the coast is formed by the Karroo formation, there are extensive plateau-like terraces bordering the coast, deeply cut into by the rivers flowing from the Stormberg and Drakensberg. At a few spots on the plateau that lies about 2,000 feet above the sea there are remains of deposits analogous to the old alluvium and quartzites of the country to the south-west. Kentani Hill is a conspicuous example of these. At the present time, however, little is known of the extent of these rocks.

In the Western Karroo a fairly well developed terrace is visible along the foot of the Zwart Ruggens, the dry mountain ridge of Witteberg beds that limits the Ceres and Tanqua Karroos. In the Tanqua Valley a corresponding terrace covered with gravel derived from the Klein Roggeveld forms a conspicuous feature on the south side of the valley.

In all these cases the gravels are coarser near the mountains than farther away from them. Pebbles and boulders derived from the Table Mountain sandstone are by far the most conspicuous constituents in the high

level gravels of the southern coastal region and in those of the country between the Langebergen and Zwartebergen. The boulders are sometimes of great size, four or five feet in diameter, and they have their edges rounded off; the smaller fragments are more rounded and are like the waterworn pebbles to be found in the modern stream beds. These fragments are embedded in a matrix that varies very greatly; in the bulk of the rock the matrix is a sandy material, but slightly hardened, from which the pebbles may be easily broken out; in other cases the matrix is deeply coloured by hydrated iron oxide, and the rock is in consequence reddish brown. Such ferruginous gravels are well developed near Genadendal in Caledon and at the foot of the Zwart Ruggens in the western Karroo. Near the village of Napier there is a conspicuous kopje formed of a dark, highly ferruginous conglomerate, which probably belongs to the same group of gravels that are developed to the west of the village, at a considerable height above the bed of the Elands Kloof River. The ferruginous cement has in many cases hardened the gravel to such an extent that the rock breaks across pebbles and matrix alike when struck with a hammer.

There is a gradual passage laterally from these ferruginous gravels to the fine-grained ferruginous rocks that lie farther from the mountains, and which often contain a few angular or subangular pieces of white vein quartz derived from the slaty Bokkeveld or Witteberg beds underlying them. Magnificent examples of these hardened alluvial deposits are to be found in many parts of the Ruggens, forming rough-looking caps on the

higher hills, such as Klaas Kaffir's Heuvel near the road from Swellendam to Bredasdorp.

The ferruginous rock is often directly underlain by white and yellowish clays, bleached by the slow removal of the iron they once contained which is now concentrated in the overlying rock. In some cases the traces of cleavage and joint planes are to be seen in the bleached material, which must then be regarded as a product of weathering *in situ* of slates; but most of the clays appear to be alluvial deposits formed by the rivers when they were at a relatively higher level than at present.

The ferruginous material is closely related to the laterites that occur at lower levels in many parts of the south-west, and which will be described on a later page.

Another very widespread variety of the gravels is due to the deposition of silica in the matrix subsequently to the formation of the gravel. All stages between a rather incoherent conglomerate and an extremely hard rock from which it is practically impossible to detach the contained pebbles can readily be found in one and the same patch of rock. The deposition of silica is most advanced on the upper surface of the mass, the lowest part of which is often a loose gravel. By the diminution in size of the pebbles and their gradual disappearance as the outcrops are followed away from the mountains the quartzitic gravels pass into the typical "surface quartzite" so widely distributed throughout the western and southern parts of the Colony (see Pl. XX.).

As a rule the surface quartzites have certain peculiarities that enable one to recognise the smallest chip without difficulty; their fracture is smoother, more con-

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the rock in the foreground is silicified gravel.

mountains,

choidal, and less splintery than that of the quartzites of the older formations; small quantities of argillaceous matter, yellow or grey in colour, are present in the siliceous matrix enclosing the grains of quartz sand that are often visible without the aid of a magnifying glass. The quartzites generally enclose many small irregularly shaped cavities, which are sometimes lined with minute crystals of quartz, or with the chalcedonic form of silica. The original quartz grains in the rocks are at places converted into bipyramidal crystals by the addition of new quartz in crystalline continuity with the quartz of the grain. By the mutual interlocking of the new quartz added to all the sand grains in the originally sandy portion of the rock, the loose sands have become intensely hard quartzites in which the original grains are no longer recognisable without the use of a microscope and thin sections of the rock, when the outlines of some of the grains can be seen within the new growth of quartz; the quartz deposited round any one sand grain interlocks closely with that round the neighbouring grains. Good examples of these quartzites may be seen in any of the south-western divisions. They often appear above the soil as rounded polished surfaces, due to the weathering out of the rock along irregularly disposed vertical joints, which leave a massive lump of rock in their interstices. On the hill-top near the road from Swellendam to the bridge over the Buffeljagt's River the quartzite has been quarried for building purposes; the bridge piers are made of it. As a rule, however, the rock is too intractable and too variable within short distances to be worth quarrying

although it is certainly a very durable stone. Near Grahamstown the surface quartzites appear in the Sugar Loaf Hill and on the terrace to the north of it mentioned on a previous page. The hard quartzite is at most ten feet thick, but the underlying soft clayey material, into which the quartzite passes without any definite break, is at places as much as forty feet thick.

The top of Kentani Hill, the only conspicuous elevation above the general surface of the plateau that stretches northwards from the Kentani escarpment, is formed by a hard quartzite, vitreous in parts, but usually with a rough pitted surface. The quartzite, which is only a few feet thick, passes downwards into variously coloured clays from thirty to forty feet thick.

A similar siliceous rock from a farm about nine miles south of Komgha village contains the silicified seeds of *Chara*, small spherical bodies with ribs passing spirally round them, and silicified shells of *Limnæa*. This is the only surface quartzite in the Colony known to contain recognisable fossils, but at present nothing is known of its extent.

On the Cape Flats there are several outcrops of surface quartzite, some of which contain plant remains that have not been determined. One well-known outcrop is near the main road to Stellenbosch about ten miles from Cape Town, and there are several others in its vicinity. The Cape Flats quartzites are usually whiter and more uniform in grain than the similar rocks in other parts of the Colony. The white colour is due to the almost complete absence of clay and ferruginous colouring matter; the quartzite passes downwards into

a sandstone and that again into loose sand, which is identical with the white sand that occurs under the surface soil over a great part of the Flats.

In the Malmesbury, Piquetberg, Clanwilliam and Van Rhyn's Dorp Divisions surface quartzites are met with in many places on the coast side of the Olifant's River Mountains and the other ranges in connection with them. The quartzites are underlain by sandy clay or gravel into which they grade. By an increase in the amount of ferruginous colouring matter they become very similar to the laterites, and on the Van Rhyn's Dorp coast they pass into coarse conglomerates containing the shells of living species of marine forms, raised beaches which lie from 50 to 100 feet above the high-water mark. This summary of the distribution and features of the high level gravels and associated rocks shows that throughout the southern, western and south-eastern portions of the Colony there are gravels and alluvial deposits, altered to some extent by the deposition of silica and other cementing substances between the grains, lying high above the levels at which similar accumulations are being formed at the present day. The deep channels through which the rivers now flow, and the consequent cutting up of the former plains whose existence is evidenced by the numerous flat-topped hills capped by the deposits laid down before the deep valleys were eroded, show that the country as a whole is now at a relatively higher level than it was during the formation of the plains. The rocks underlying the remnants of the old plains, now exposed in the river valleys, are of various natures and in part intensely

folded. The more resistant of these, chiefly the Table Mountain series, still project above the general surface of the plains in the great anticlinal ridges that have so frequently come under our notice. The terraces cut into these ridges show that the great anticlines of quartzites and sandstone were being attacked, and had to a slight extent been reduced to the level of the plains, at the time when the country began to rise and give renewed downward eroding power to the rivers. Previously to this period of elevation the country as a whole must have stood for long ages at about the same level, unless, indeed, some slight downward movements broke the quietude. The rivers were thus enabled to erode their valleys laterally after they had reached their base levels, *i.e.*, when the slope of their valleys was such that they could carry away all the debris furnished them but were unable to deepen their channels.

Towards the close of the period of great lateral erosion large areas south of the Langebergen, west of the Cederberg group of ranges, and between the Langebergen and Zwartebergen, were reduced to gently undulating surfaces, across which the rivers flowed with many bends in their courses, and they were bordered by low-lying land covered with gravel near the mountains and sand or loam farther away from them. Probably there were many damp and swampy patches, or even shallow lakes, such as would be called vleys in this country, on the low land, and in these places the changes may have commenced that resulted in the formation of the surface quartzites.

From an examination of specimens sent to Europe by Dr. Passarge, Professor Kalkowsky[1] came to the conclusion that a certain kind of rock, which seems very similar to our surface quartzites, was formed by the silicification of an aluminous sandy mud deposited in salt pans in the Kalahari. The addition of the silica is attributed by him to the action of salts and organic substances in solution upon the silicious remains of diatoms and other plants, although the diatoms were not actually found in the rocks examined. This explanation may apply to the Cape surface quartzites, for it fits in with the sporadic occurrence of the rock.

2. The newer gravels and alluvial deposits.

At various levels between the high level deposits just described and the beds of the present rivers in the southern, eastern and western parts of the Colony there are more or less well-marked terraces covered with gravels and alluvium. Several such terraces can be seen along the Breede River below Swellendam. It is often difficult to separate the higher of these from the high gravel plateaux, and hard ferruginous rocks and even quartzites may be found on them, but they may often be distinguished from the plateau gravels by the finding of pieces of the quartzitic or ferruginous gravels amongst their pebbles. The Breede River terraces have gravels containing such pebbles and boulders derived from the older deposits, originally of a similar nature.

In some parts of the Swellendam, Riversdale and Mossel Bay Divisions, the gravels met with far from

[1] Kalkowsky (01), p. 55, etc.

the mountainous ground often contain large pebbles derived from the conglomerates belonging to the Uitenhage series. These pebbles were well rounded, and were probably in much the same condition as they are to-day, before they reached their present position. The same is the case in other districts, such as Oudtshoorn, where the Uitenhage conglomerates occur. The abundance of these derived pebbles in positions where an explanation of their presence would be very difficult on the supposition that they were brought directly from the original source of the rocks of which they are made, is at places very striking.

Near the mouths of many of the rivers of the south and south-east coasts there are sandy deposits which extend to a considerable depth below the beds of the rivers. At the Bitou River[1] the green sands containing many marine shells, including large numbers of *Cryptodon globosus*, which is now comparatively rare in the adjacent sea, were pierced to a depth of forty-seven feet below the river without their base being found. The shells hitherto found in these sands and in similar deposits in other places all belong to existing species. At East London the sandy mud in the estuary of the Buffalo River has been found to be over 120 feet thick. The considerable depth below sea level to which these estuarine deposits extend may point to a subsidence of the coast, but it is perhaps more likely that the scour of the river and tide combined are sufficient to account for the excavation of the estuaries. This certainly

[1] Schwarz, *Geol. Comm.* (99), p. 61.

seems to be the case with the short but deep estuary of the Kaaiman's River, near George, where there is a rapid fall of the bed below the old road drift.

The alluvium along the great rivers draining the Great Karroo is often extensive and of considerable depth. It occurs chiefly behind mountain ridges through which the rivers have cut their way more slowly than in the softer ground now occupied by the alluvial deposits. A very good example is found in the Olifant's River (Oudtshoorn); this river rises south of Antonie's Berg in Willowmore, but it receives very important tributaries in the Traka, Meiring's Poort, Grobbelaar's and Kammanassie Rivers before it joins the Gamka in the middle of the Roode Berg mass of Table Mountain sandstone. The junction of these two rivers makes a great Y-shaped gorge, with vertical walls some 600 feet high, in the heart of the mountains. Before entering the gorge the Olifant's River runs for some eighty miles over flat country, and this tract is very rich in alluvium, especially the lower part of it below the town of Oudtshoorn. Underlying the alluvium there are rocks belonging to the Uitenhage group, which are soft and easily eroded compared with the Table Mountain sandstone. The mountains have acted as a check to the downward cutting of the river, that has consequently widened its valley behind them and deposited the alluvium to which the Oudtshoorn Division owes its wealth. These accumulations are gathered from nearly all the rock systems in the Colony, from the Pre-Cape rocks of the Cango to the Uitenhage beds of their immediate vicinity. The Gamka has formed a similar

but smaller alluvial tract between Sand Berg (or Paarde Berg) and the Roode Berg gorge, and others occur lower down its course.

Another tributary of the Gamka, the Buffel's River, has cut a wide alluvial plain behind the Klein Zwartberg, which it enters at Leeuw Kloof Poort.

Great tracts of alluvium are found along the rivers which flow northward from the main watershed to the Orange River. The great Fish, Rhenoster, and Zak Rivers in Sutherland, Fraserburg, and Calvinia, are especially rich in alluvial deposits derived from the Beaufort beds and the dolerite north of the watershed. Where water can be easily brought on to these lands they are extremely fertile. Tontelbosch Kolk in Calvinia, a farm on the banks of the Rhenoster, is perhaps the finest grain farm in the Colony. The fall of these tributaries of the Orange is very slight compared with that of the rivers south of the main watershed; their valleys are more open, and towards their lower ends tend to disappear in the pans or "vloers," the flat alluvial ground quickly flooded during storms but baked hard and white a few hours later, that are a characteristic feature of the arid country south of the great river. In the western Karroo the rivers draining the Roggeveld escarpment receive a sudden check on leaving the Karroo formation and entering the region of the Witteberg beds, which are of a harder consistency. In the Bosch River Valley on Witte Vlakte a well has been sunk 140 feet through alluvium without reaching solid rock; this river has deserted its former channel, now marked by a very conspicuous poort in the beds west of the Poortje

pan, and has turned southwards to enter the Draai Kraal's River several miles from its former point of junction.

The rivers of the west coast, from the Great Berg to the Olifant's, have considerable tracts of alluvium along the lower forty miles or so of their valleys. The Berg River alluvium extends to a depth considerably below sea level at many spots where wells give information bearing on the question.

Very little is known of the fossil contents of these river deposits, many of which are of quite recent origin and therefore probably contain only the remains of living or lately extinct animals. The imperfect head of a gigantic buffalo,[1] *Bubalus baini*, Seeley, measuring eight feet six and a half inches between the horn-tips, although these are broken and therefore shorter than they were originally, is preserved in the South African Museum, and seems to be the only known example of an extinct mammal from the river deposits. It came from the Modder River, forty feet below the surface.

3. In many parts of the southern and western coast districts there are layers of ferruginous rock resting either immediately upon the slates, granite, or other rock of the vicinity, or with the intervention of a few feet of sandy clay. The underlying rock is usually considerably weathered, and sometimes bleached by the loss of its colouring matter, which seems to have been transferred to the ferruginous layer. The latter varies very greatly within short distances. It is usually a

[1] Seeley (01), p. 199.

hard lumpy-looking rock, with innumerable small and irregular channels lined with a red-brown or yellow material. In places the hydrated sesquioxide of iron, limonite, is so free from sand and clay that it might be used as an ore; but generally there is a large quantity of clay, sand, and subangular fragments of vein quartz and other rocks that do not decompose under the influence of the weather, cemented together by the iron oxide.

Along the edges of the Cape Flats near the high ground of the Peninsula and the Tyger Berg the laterite, or ironstone as it is usually called, is found a few feet below the surface. Farther inland, in the Malmesbury, Paarl, Caledon and other Divisions near the coast, where there is no general covering of sand as on the Cape Flats, the laterite lies just below the soil, or is exposed at the surface, over considerable areas of flat and slightly inclined ground. It is rarely or never found in its typical form on steep slopes, although even in such situations the subsoil is in places partly cemented into a fairly hard substance by ferruginous matter, thus making an approach to the laterite of the lower ground.

The formation of the laterite is due to the concentration of the iron oxide near the surface in the decomposed rock or subsoil, occasionally in sandy soil that has been brought to its present position by water. The nature of the clay that accompanies the laterite in many places, especially where it lies upon clay slates, has not yet been ascertained.

The high-lying lateritic rocks are closely connected

with the older gravels and alluvial deposits, and are now represented by mere remnants, but the low-lying ones are to-day in process of formation.

Very similar looking laterites appear to have been derived from rocks of diverse natures, such as granite and slate; even the Table Mountain sandstone of the west coast, Clanwilliam and Van Rhyn's Dorp, is in places covered with a ferruginous cemented material grading on the one hand into the raised beaches of that coast and on the other into the surface quartzites. Near Strand Fontein, a few miles south of the Olifant's River mouth, the almost flow-like appearance of the remains of the dark limonitic quartzite lying on the Table Mountain sandstone and filling up the open joints at various levels from that of the high tide to 200 feet above it has given rise to the idea amongst the people in the neighbourhood that it is lava. This somewhat remarkable variety of the lateritic rocks is certainly due to the deposition of the hydrated iron oxide, leached out from the underlying sandstones, between the sand grains which reached their present position through the agencies of wind and water.

4. Extensive areas in various parts of the Colony are covered to a more or less considerable depth by sand. These deposits of sand may be roughly divided into two groups; those formed inland and those near the coast.

The inland sands are chiefly developed in the north-west; the Namaqualand, Calvinia, Kenhardt and Prieska Divisions contain large tracts of sand, and the same is the case with the great dry country formed by the Colonial portion of the Kalahari Desert. Little is known

from a geological point of view of much of this country, especially of the Kalahari region. The sand occurs in the form of well-defined ridges in the Kalahari and in the more arid parts of the country south of the Orange River.

In Bushmanland (parts of Namaqualand, Calvinia and Kenhardt) the sand is derived from the minerals composing the gneissose granite that occupies such wide areas there. Quartz and felspar are the chief constituents, and by the breaking up of the granite under the influence of the great diurnal change of temperature, one of the climatic features of that region, the minerals are set free to be carried about by the wind and rain. The sand is pink owing to the abundance of red felspar, and also to the iron oxide derived from the ferruginous constituents of the igneous rocks, biotite, hornblende, hypersthene and magnetite.

In Prieska the granite, gneiss and mica schist areas are usually covered with deep sand; the more compact rocks, the quartzites of the 'Keis group and the Griqua Town and Campbell Rand beds, disintegrate less rapidly than the rocks just mentioned, and do not yield so much sand.

There is much sand in the valley of the Orange River, where it forms extensive dunes in favourably situated spots. This sand is blown from the river banks at times of low water.

In the district between the Olifant's River mouth and the Berg River, as far inland as Piquetberg and the Olifant's River Mountains, there is a great quantity of sand. The country is known locally as the Sand Veld.

The underlying rock is chiefly Table Mountain sandstone, although the southern part of the area is probably underlain by the Malmesbury beds. The whole area is characterised by a remarkable scarcity of running water and even of definite stream beds, although the southern part at least has a fairly heavy rainfall; the northern portion is much drier, but the absence of stream beds is due to the rapidity of absorption of the water by the ground and not to the lack of rain. From the Berg River to the Olifant's, a distance of some seventy-five miles in a straight line, there are only five stream beds to be found; the Zout, Verloren Vley, Lange Vley, and Jackal's Rivers and the Zand Leegte. The Zand Leegte is a very well-marked valley about twenty miles long, commencing near Konaqua's Berg and terminating on the coast at Strand Fontein. The lower part of the valley is almost a gorge, some 180 feet deep, and at places only a few yards wide at the bottom, cut out of the hard Table Mountain sandstone. No water has been known to flow down this valley during the period covered by tradition in the district, perhaps 150 years, although a severe thunderstorm sometimes—about once in fifteen years—makes a stream of short duration in its upper part. The valley is being filled in with sand chiefly brought there by the wind. It is decidedly a striking proof that the district is drier now than it was at no very remote period, for there is no doubt that the valley was cut by a stream, and it was made since the advent of the still-living species of mollusca; for at the mouth of the gorge a raised beach lies about 100 feet above sea level, and appears to have stretched across the

ravine; the raised beach contains the shells of mollusca of the same species as those found on the modern beach in addition to the water-worn pebbles and boulders that make it a conspicuous feature on the top of the cliffs.

The evidence afforded by the Zand Leegte will explain the development of the Sand Veld. The tops of the sandstone hills still project above the sand, but the old valleys, that were carved out by rivers before the climate became as dry as it now is, are almost entirely filled up by the sand derived mainly from the sandstone hills and from the mountains built of the same rock to the east of the Sand Veld. Where exposed to constant sifting by the wind the sand is white or very light-coloured, but throughout the greater part of the area it is reddish. The red colour is certainly due to oxide of iron, but the source of the iron is not so evident. In sinking wells it is found that the lower layers of sand are paler in colour than those near the surface; it may be that the rain water, with the aid of organic compounds taken up during its passage through the soil, dissolves the iron oxides deep under the surface and brings them in solution to the top where it leaves them as thin films round the sand grains on evaporation. But it is possible that the very fine red dust brought into that part of the country by the strong east winds will account for the red colour of the surface sand. The fertility of the Sand Veld is remarkable, considering the general appearance and nature of the soil, good grain crops being obtained when average winter rains fall; it is probable that the wind-borne dust adds the necessary constituents to the otherwise extremely poor soil.

The Sand Veld sand passes somewhat abruptly into

the dunes that line the west coast. The proximity of the coast makes itself noticeable by the increase of calcareous matter in the sand ; the carbonate of lime is derived from marine shells which are pounded to dust on the shore and then blown inland.

Patches of sand dunes of greater size than usual are found south of Saldanha Bay, on the shores of False Bay whence the sand has invaded the Cape Flats, near the Bot River mouth, at Cape Agulhas, Cape Barracouta and Cape Recife. These are calcareous sands composed of a mixture of broken shells and fragments of minerals, chiefly quartz. The strong winds and constant supplies of fresh sand, as well as the facility with which the dune sand is moved, account for the difficulty of getting vegetation to gain and maintain a footing on these sand areas, which are a source of danger to the farms behind them.

5. The calcareous sands of the coast belt pass into limestone by the solution of carbonate of lime from parts of the mass, and its deposition near the surface when the water evaporates. In almost any part of the south-coast dunes a thin hard crust can be found covering sand which has been protected from the wind for some time ; it may be less than a quarter of an inch thick, and is easily broken. By the long-continued deposition of the carbonate of lime the sand dunes are converted into hard rock through a distance of many feet from the surface, and where repeatedly wetted and dried, as happens when the sea has encroached upon old dunes, the rock becomes intensely hard and weathers with a peculiarly jagged surface. At Hoetjes

Bay, an inlet of Saldanha Bay, the limestone derived from hardened dunes has been quarried for building stone, and furnished the material of which the General Post Office and South African Museum are mainly constructed. In the large quarry at Hoetjes Bay the gradual hardening of the stone from the deepest portion exposed towards the exterior is well seen. This limestone contains a smaller proportion of quartz sand than usual, about 12 per cent., but the composition varies considerably according to the amount of carbonate deposited between the original grains of the rock, and also according to the proportions of broken shell and particles of non-calcareous minerals in the original sand.

False bedding is a very marked feature in many sand dunes, being perhaps better developed in wind-borne accumulations than in sediments deposited under water. Magnificent examples of this structure can be seen in several cliff sections through the hardened dunes on the south coast between Cape Agulhas and Mossel Bay, and again to the east of Algoa Bay.[1] Plate XXI. is from a photograph of a cliff near Struys Point on the Bredasdorp coast.

In addition to the usually fragmentary remains of marine shells the dune limestones contain many fossils of animals that lived upon land, and these are in a much more perfect condition than the former. Snail shells, especially a large species of *Helix* that is commonly found living near the coast, are abundant in the limestones of Saldanha Bay and the south coast.

[1] Atherstone (58).

PLATE XXI.—False-bedded limestone near Struys Point, Bredasdorp.

Mammalian remains are frequently found, and they include species such as the elephant, rhinoceros and eland, that are no longer living in the neighbourhood. Hitherto no extinct forms have been discovered in any of the coast limestones.

In the Bredasdorp Division there is a prominent range of dune limestone hills stretching from near the village to Cape Infanta.[1] In their western part the hills lie some twelve miles from the coast, and are separated from it by a tract of low ground; near the coast the country again becomes hilly owing to the modern dunes. The inland range must be of considerable antiquity, and it is now being destroyed by the weather and rivers without receiving any fresh material to compensate for this loss. These old dunes were formed at a time when the coast was at a lower level than now, during the period represented by raised beaches in several parts of the Colony.

The dune limestones are in places rather easily disintegrated, and weather very unequally, hence shallow caves are of frequent occurrence in them. At Cape Infanta there is a fairly large cave with a small entrance on the cliff; the roof is hung with stalactites, long tapering tubes of calcite deposited from the water percolating through the overlying limestone, and the floor is formed by a mixture of sand and bat-guano. The origin of the cave was probably due to a stream that no longer exists. This cavern is perhaps the largest (some 150 feet long and 20 feet high in parts)

[1] For a more detailed description of these and allied rocks see Rogers and Schwarz (97), p. 427, etc.

yet found in the dune limestones. Other caves of considerable depth, such as the Kellers near Danger Point, have streams of water still flowing through them.

6. On the coast side of the Langebergen there is frequently a thin layer of whitish impure limestone immediately below the soil, and a similar rock covers wide areas in the western portion of Malmesbury and Piquetberg. It is possible that some of this represents dune limestones that have disappeared, or it may be due to the slow accumulation of shell fragments blown inland from the coast. The calcareous layer is especially well developed between the Kaffir Kuils and Gouritz Rivers in Riversdale. There is a particular variety of the limestone seen in the soil about a foot below the surface that is now in process of formation. This is a nodular rock, rather compact, and it contains numerous sand grains and other particles derived from the soil. The calcareous matter collects together in certain spots and forms irregularly shaped lenticular lumps; neighbouring masses coalesce and produce layers. The bulk of the clayey material in the soil seems to be pushed aside by the calcite, but the sand grains remain behind. This rock is well shown in some of the railway cuttings berween Heidelberg and Riversdale. It is similar to the "Kankar" of India.

The springs that come from the Bokkeveld series and from the Karroo beds frequently deposit a white tufaceous limestone which forms irregular layers in their neighbourhood, filling up the joints of the exposed rocks and cementing together the particles of soil. The

springs are usually weak and in the course of time block up the channels through which they flow by the deposition of the tufa. Thus many patches of limestone occur without any sign of water. The farmers are aware of the connection between the tufaceous limestone and spring water, and are often successful in opening up springs by removing the surface and following up any traces of water that may appear. It is quite clear, however, that the process of filling up of the joints through which the water flows may have gone on so far that the attempts to release the water will be unsuccessful; or, again, the water may have found another exit at a lower level.

The sediments of the Karroo formation contain a fair proportion of carbonate of lime, and the dolerite which is so abundant in the form of intrusions in these beds contains about 10 per cent. of calcium oxide; this, on the decomposition of the dolerite, is chiefly converted into carbonate of lime. From these two sources the impure limestone that is so widely spread between the main watershed of the Colony and the Orange River has chiefly been derived. Every heavy rain that carries the products of decomposition from their place of origin to the flat ground, and especially to the shallow pans, brings with it some carbonate of lime which it leaves behind on evaporation. To this source must be added the slow creep of water towards the surface by capillary attraction and the influence of plants.

The thick calcareous tufas that are found in the Orange River Valley, as in the neigbourhood of Hope Town, were probably deposited in pans that have been

cut through by the Orange River; but at present very little is definitely known of the nature and extent of these old tufas.

7. At many places on the coast there are beaches of rolled pebbles, sand and shells at various heights above the present day shore. These deposits frequently rest upon a more or less extensive shelf cut into the sloping land behind the shore.

The most northern raised beaches yet found in the Colony are on the coast between the Olifant's River mouth and Thorn Bay. The coast is formed by a range of cliffs about 100 feet high, composed of the Malmesbury beds to the north of Strand Fontein and of Table Mountain sandstone to the south. South of the Zand Leegte the cliffs are remarkably fine, and they are broken into many small inlets and rocky points by the attacks of the Atlantic waves. The Table Mountain sandstone dips eastwards at about 35°, and is cut flat on the top of the cliffs. The old beach deposits lie on this flat surface, and consist of water-worn boulders mixed with sand. The beach has been cemented into a hard conglomerate by the deposition of iron oxides and siliceous matter in places, and in these conglomerates shells or fragments of them are scarcely to be found; but in other parts of the beach at the same level, where this process has not gone so far, shells belonging to species still living on the west coast are abundant, and the rock is a loose shelly conglomerate. Transitions from the latter to the former condition of the beach are to be found, and as the amount of change increases the shells decrease in quantity; they are dis-

solved without being accurately replaced by the cementing material.

On the peninsula to the west of the south end of Saldanha Bay there are shelly limestones with abundant shells of living marine forms lying from ten to twenty feet above high water. These limestones pass inland into the hard dune limestone with land shells. They are an old beach formed when the land stood somewhat lower than at present. It is a curious fact that the dune limestone passes below sea level in Saldanha Bay and on the south coast; this rock on careful examination is always distinguishable from the calcareous beach deposits, and its occurrence below sea level in the same districts as the raised beaches points to a slight sinking of the land since the beaches were formed and elevated.

In the Cape Peninsula there are a few patches of supposed beach deposits at a height of from 50 to 100 feet above the sea. They contain the remains of living species of mollusca. It is a curious fact that no shell-bearing sands or other recent marine rocks have been discovered below the Cape Flats, but they certainly should be there if the correct interpretation has been found for the deposits just mentioned from the Peninsula.

In the neighbourhood of Hermanus there is a very well-marked rock shelf between the Klein River Mountains and the coast about fifty feet above the sea. It is a wave-cut terrace of Table Mountain sandstone, covered in places with dune limestone. Similar terraces are to be found near Danger Point, Zout Anys Berg and Pot Berg. At Cape Infanta there is a raised beach at the base of the dune-limestone, which there forms high

cliffs. The beach conglomerate is about 100 feet above the sea. On the shores of Algoa Bay there is a well-developed terrace cut through the Uitenhage beds, it slopes gradually towards the sea from a height of about 400 feet above high tide in its inland portion to 200 feet where it is concealed under the blown sand of the coast. The shelf is covered in places with shelly conglomerates containing the remains of mollusca still living off the South African coast. A characteristic shell in this deposit is a very large *Pectunculus*. At lower levels nearer the sea there are patches of old beaches which contain shells belonging to living species.[1] Many of these raised beaches contain numerous species of shells, and the careful collection and determination of these from the different deposits is certain to yield interesting results.

Near the mouth of the Buffalo River there is a layer of earthy clay 200 feet above sea level containing remains of recent shells; it was regarded by its discoverer, Mr. McKay, as a marine deposit, and he found a fragment of native pottery in one of the shell layers.[2] This fragment of pottery is the only recorded evidence of human occupation of the country at the period of these raised beaches and allied deposits, but before it can be accepted as good some corroborative facts should be brought to light elsewhere.

Although the evidence bearing on the question of a

[1] The best account of these deposits is still that of G. W. Stow (71), pp. 515-22. A list of species found in the low level beaches near Port Elizabeth has lately been published by J. P. Johnson (03), pp. 9-11.

[2] Quoted by Huxley, *Scientific Memoirs*, vol. iii., p. 300; also *Geol. Magazine*, 1868, p. 201.

recent change in level of the whole coast line is so widely distributed much remains to be done before it can be fully understood. So far as it goes it is in accordance with the presence of the river-cut high-level plains now deeply channelled by the existing streams. There is good reason to believe that while these plains were being made the higher raised beaches were also in process of formation. In the Swellendam Ruggens, for instance, the old gravel and alluvial plateau that slopes gradually towards the coast and is trenched by tributaries of the Breede River terminates at the foot of the Bredasdorp limestone hills, which we have seen were once calcareous sand dunes. These are continued into the limestone that overlies a pebbly beach deposit at Cape Infanta, now being cut back by the sea. At the time when the inland plateau was being cut the dunes that now form the limestone range were being piled up by the wind, and the coast was indented by a broad bay between Cape Infanta and Bredasdorp village. The eastern corner of the bay extended farther seawards than the present position of Infanta, for the high cliffs made of Table Mountain sandstone in their lower part and of the beach deposit and limestones in the upper half must have been undergoing destruction ever since the raised beach was removed from the reach of the sea.

In the Algoa Bay region the high-level gravels of the Zwartkops Heights were probably formed at the same time as the terraces covered with surface quartzites and allied deposits near Grahamstown, and the wide rock terrace traversed by the main road from Port Elizabeth

to Humansdorp. The upward movement of the land which raised the Zwartkops Heights beach to its present level also brought about the renewal of the downward erosive power of the rivers inland, so that they trenched the gravel and quartzite plateau of Grahamstown.

8. Near their mouths many South African rivers expand into wide shallow lagoons. The larger rivers, such as the Berg, Breede, Gouritz, Kei and St. John's, which maintain open channels to the sea throughout the year, have comparatively small lagoons or none at all, although some of them, such as the Berg, give rise to shallow vleys beyond their banks in times of flood. The smaller streams whose mouths are more or less regularly choked up by sand bars terminate in vleys of various dimensions. The formation of a wide vley in place of a sharply defined channel is easily understood; the water flowing into the lagoon cannot escape quickly, but filters slowly through the sand bar; it therefore stands above the sea level, and owing to its constant movement it laps against the usually soft sandy banks and gradually washes them away, depositing the debris in the deeper portions of the channel. The absence of an open mouth prevents the tide from assisting to keep the channel clear. The mud brought down by the river mingles with the sand blown or washed by rain into the vley and makes a sandy loam, which tends to form a flat surface somewhat above sea level, so that should the mouth become open for a long period the river will flow through a flat alluvial tract just before entering the sea. Such may be the origin of the flats at the mouths of the Zwart Kops and of the Great and Klein Brak Rivers in

Mossel Bay. The same feature is seen at the Kowie mouth, although in this case the channel is maintained by the walls built for the harbour. The Bot and Klein Rivers in Caledon and Bredasdorp have large vleys, which are only open after the winter rains. Many large lagoons, such as Zoetendal and Salt River vleys in Bredasdorp, have quite small rivers flowing into them, and are very rarely open to the sea. Zoetendal vley is fed by two rivers, and near the mouths of one of them a small stream flows to the sea at certain times by a longer route than would be afforded by the vley if it were open to the sea near Northumberland Point. In the Transkei and Pondoland very many small streams rarely bring down enough water to break through their sand bars, and in time they will form corresponding alluvial tracts with small channels traversing them. The comparatively recent elevation of the coast that enabled these rivers to cut deep valleys through the coastal plateau has not been of sufficient duration to allow them to silt up their lagoons.

A vley is sometimes formed along the course of a river just behind a ridge of rock that is with difficulty cut through by the stream. The softer rock behind the obstruction allows the river to cut out a wide plain, and by the unequal distribution of debris over the plain the bed of the stream may be raised slightly above the level of the plain, causing the latter to be flooded at times. A process of this sort has taken place in the valley of the Bosch River where it approaches the Bokkeveld hills west of Witte Vlakte. An extensive vley or pan, on the farm named Poortje, is the result, and the river has found

an easier course to the south, where it joins the Draai Kraal's River.

Very extensive vleys, which rarely have any water in them, are formed along the rivers entering the Orange River from the south. Not much is known as yet about these great "vloers," but they are probably due to the flooding produced by blown sand obstructing the rivers, which tend to distribute their silt over wide areas and thus to level up their valleys, that have a very gradual fall.

The water that gathers in these river vleys is somewhat brackish from the salts derived from the surface soil in their drainage basins, but these vleys do not seem to contain salt deposits of any value as a source of that commodity.

There is another class of pan, not obviously connected with the river vleys, whose origin is more difficult to account for. There are two subclasses of these; the first consists of the pans near the coast, and the second of those lying far inland.

The pans on the coast are usually at a low level, separated from the sea by a belt of sand dunes. There are several of these on the west coast south of the Olifant's River. Rain water collects in them, and owing to there being sufficient clayey matter or limestone round them the water does not drain away but evaporates slowly, leaving a thin crust of salts, mostly composed of sodium chloride or common salt. Usually the thin crust is not sufficiently free from sand to be used for domestic purposes, so shallow trenches are dug in the floors of the pans during the dry season and a deposit

of salt three or four inches thick is formed in them after the rains. The salt is probably collected by the rain water in its course through the surrounding sandy soil, which receives it gradually from the sea in the form of spray or attached to the grains of sand blown from the shore.

On the coast of Bredasdorp there are several productive pans. Some of them are within a short distance of pans which contain fresh or nearly fresh water only, yet no difference in the conditions of the salt and fresh vleys is observable. This fact is difficult to explain on the supposition that the salt is washed into the pans from the surrounding soil; but at no distant period the low-lying parts of the Bredasdorp coast must have been under the sea, or at any rate liable to inundations of salt-water at high tide during storms, and it is possible that the salt derived from this source is still inexhausted in spots where, owing to a slightly lower level or to the presence of more favourable surface deposits, a larger quantity of the sea water evaporated than elsewhere.

Perhaps the richest pan in the Colony is that on the Zwartkops heights north of the river of that name. The pan is surrounded by the shelly beach deposits described on page 381, and is underlain by the Sunday's River beds. An enormous quantity of salt is taken yearly from this pan, yet it shows no sign of exhaustion. The salt must come from the rocks close at hand, and as no beds of rock salt are known to exist in the Sunday's River beds, or indeed in any other formation in the Colony, it seems certain that it is derived from the recent beach deposits.

The inland salt pans are mostly found near the Orange River, where vleys are abundant. A great stretch of country, extending from the north of Calvinia through the Divisions of Kenhardt, Fraserburg, Carnarvon, Prieska, Hope Town and Kimberley, is particularly rich in more or less circular pans of various sizes, from a few yards to a few miles in diameter. This tract is sometimes called the Panne-veld, and coincides roughly with the outcrop of the Dwyka conglomerate, a rock that is less permeable than either the sandstones and shales that lie south and east.

The salt in these inland pans must be derived from the surrounding rocks. There is no evidence that the interior of the Colony has been under the sea, or indeed under water of any kind, since the close of the Karroo period, and that water was probably not salt. There is very little information as to the composition of the salt from these pans, but sulphates (of calcium and magnesium) as well as chlorides are present.

In a pan at Klip Fontein's Berg, in Clanwilliam, the depression, from which common salt is gathered for domestic purposes, is surrounded by a thick layer of carbonate and sulphate of lime. The sulphate of lime (gypsum), occurs in small and large crystals embedded in a calcareous, sandy mud, and it forms the larger part of the deposit. The material is well stratified, and the layers are thin.

The coast pans owe their existence to the barrier of dune sand blown up from the shore, but an adequate explanation of the inland pans has not yet been given.

The Recent Deposits and the Human Occupation of the Country.

Except in the case of the piece of pottery found in the high-level marine clay of East London no human remains have been found in any of the higher raised beaches, or in the quartzites or other deposits on the higher plateaux. The surface quartzites indeed furnished the favourite material of which the aborigines made their rough knives and other implements with a more or less sharp edge, proving that this rock was available at an early period of man's occupation of the country.

By far the greater number of stone implements are found either upon the surface or at a small depth within the soil, and specimens that in Europe would be regarded as of Palæolithic type, *i.e.*, roughly fashioned without ground or carefully chipped edges, may well have been in general use during the early years of the European settlement. Although the use of the round stones with holes through them as make-weights to digging sticks amongst the Bushmen is recorded by Burchell [1] and other travellers, the use of stone axes or weapons of the nature of the stone "celts" found in Europe does not appear to have been seen.

In the south-western districts from the Peninsula to the Olifant's River stone implements with a pear-shaped or oval outline are not infrequently met with. Any hard close-grained stone was used for their manufacture, but the surface quartzite seems to have been the most abundant and suitable stone. Amongst many

[1] Burchell, *Travels in South Africa*, vol. ii., p. 29.

specimens collected in any place in that area or in the Karroo a few made of the chert from the Upper Dwyka shales are nearly always found. In the north of the Colony the jaspers of the Griqua Town beds and the cherts of the Campbell Rand series seem to have been most widely used.

In the coast districts the stone implements are often found lying with the remains of edible marine shells and fragments of coarse pottery at various heights above the sea. The abundance of shells in such "middens" is liable to make a casual observer think the deposit is a raised beach. In the Transkei and Pondoland the making of these middens by Kaffirs can be seen on most days, but especially at spring tides. The natives collect the shells, carry them to a convenient spot close to the shore, and there remove the edible portions which they take back to their kraals in baskets or cloths, leaving the shells behind. In this way astonishingly large piles of more or less broken shells accumulate in course of time.

In the inland area the implements are chiefly met with near streams or springs, on flat-topped kopjes in the Karroo, and near the caves in the mountains. The presence of small fragments of stones unlike any that crop out in the immediate neighbourhood is the sign that more or less well-fashioned cutting or scraping implements and stones used for rubbing or digging may be expected.

In the drier parts of the Colony the surface of an implement that lies uppermost is generally coated with the thin varnish-like glaze that forms on exposed rocks under the influence of the weather in such places. It

is not known how long a piece of rock must be exposed before it gets this glaze, so its occurrence does not enable us to settle the minimum age of an implement.

In all the occurrences above mentioned, with the exception of Mr. McKay's pottery which must at present be regarded with some scepticism, there is nothing in the position of the chipped stones to indicate their great antiquity. A few years ago, however, Mr. Péringuey, the Assistant-Director of the South African Museum, found a large series of rudely shaped stones in certain gravels at a considerable height above the present levels of the valley bottoms in the Stellenbosch district. Details of these finds have not yet been published, but there is no doubt that the stones were fashioned by human hands, or that they occurred several feet from the surface in old river gravels that must have been laid down at a period far removed from the present according to human reckoning, but less ancient than that of the high level plateau gravels and quartzites. The implements vary in size, but they are remarkably large on the average; one is as much as fourteen inches long. They are more or less symmetrically formed, with one end more pointed than the other. Many of them were evidently made by chipping water-worn boulders of suitable shape. They are all made of compact quartzite or hard sandstone, probably from the Table Mountain series. This interesting discovery opens up a wide field for investigation, and the pursuit of it will assuredly give us some definite knowledge of the earlier phases of man's occupation of South Africa.

Hot Springs and Their Relation to the Structure of the Country.

Springs from which water issues at temperatures considerably above that of the air[1] are rather numerous in Cape Colony. Some of these yield water of much the same composition as ordinary spring water; the Brand Vley, Olifant's River (Clanwilliam), and Montague springs are of this kind. The water from the Caledon springs contains much ferrous carbonate, and the Warm Water Berg spring water has a smaller quantity of the same salt in it. Sulphuretted hydrogen is a constituent of the Malmesbury, Cradock, and Graaff Reinet mineral waters.

The majority of these springs rise in Table Mountain sandstone areas, but their distribution is not connected obviously with the great dislocations or folds visible in that formation; there is no spring situated on or near the largest strike faults, those of Worcester and the Cango, nor does one occur in the more intensely folded portions of the east and west ranges south of the

[1] Detailed information on the contents of the water from some of these springs will be found in Krauss (43), Gumprecht (51), Noble (93), and Daniell (95), and in prospectuses issued by their present proprietors. A systematic examination of the waters, not only for their saline constituents but also for the gases containing rare and radio-active substances would be of great interest. The temperatures of some of the springs are the following:—

Brand Vley 145° F.	Malmesbury 88° F.
Caledon 120° F.	Cradock 86° F.
Olifant's River (Oudtshoorn) 114° F.	Koega 79° F.
Montague 112° F.	

These figures are taken from the papers cited; Dr. R. Marloth of Cape Town kindly gave me corroborative information concerning many of them.

Karroo. The Olifant's River (Clanwilliam) hot-bath is on the eastern limb of the gentle anticline that forms the Cardouw Mountain; the hottest spring, that of Brand Vley, is near the locality where the dip of the Table Mountain sandstone south of Worcester changes from north to east; the Caledon, Warm Water Berg, Montague, and Olifant's River (Oudtshoorn) springs issue from the sandstone on the flank or at the end of anticlines.

The Malmesbury spring flows from a mass of granite, and those of Cradock, Graaff Reinet (cold) and Aliwal North from the nearly horizontal Karroo formation in the great interior basin. It is remarkable that the Malmesbury and Karroo mineral springs contain sulphuretted hydrogen, while the others do not. This gas, in small quantities, is given off by many of the ordinary springs in the Karroo, and is probably derived from the decomposition of pyrites. Whether the gas in the hot springs has a similar source is of course not known.

The probable reason of the high temperature of the springs is that the water comes from great depths. So far as one can judge from the surface geology none of the springs is in any way connected with volcanic action. Many of the older travellers took the dark slaggy-looking deposits of hydrated ferric oxide at Caledon for lava, but the dark rock is derived from the ferrous carbonate in the water by oxidation on contact with the air. In the western Karroo there are several cold springs at the foot of the Zwart Ruggens that leave a similar deposit of limonite, but there is hardly sufficient iron in the water to make it taste unpleasant.

CHAPTER XI.

THE GEOLOGICAL HISTORY OF THE COLONY.

EVEN under the most favourable circumstances it is a difficult task to decipher the records of the past in such a way as to make clear the evolution of a country from the earliest times to the present day. By the "earliest times" we mean the period at which the lowest or oldest of the sedimentary rocks, recognisable as such, were deposited. All over the globe these ancient rocks have been found to possess characters that cannot be looked upon as original, but which must be regarded as having been produced by metamorphism due to great pressure, heat, the action of percolating water, or all three combined.

In the Cape Colony many of the rock groups classed under the heading "Pre-Cape rocks" have been altered by these agencies, and no attempt can be made at present to unravel the history recorded by them. We have no idea, for instance, where the land lay from which the sediments were brought to build up the quartzites, slates and schists of the 'Keis or Malmesbury series. Since their deposition they have been intensely folded, invaded by enormous masses of granite, and then subjected to long periods of denudation. The cases of the Campbell Rand, Griqua Town, and Matsáp series

are not much better; but we know that some of the rocks belonging to the two former came to rest again as pebbles in the Matsáp beds. There is reason to believe that the Ibiquas and Cango series derived some of their materials from the older Malmesbury beds and from the granite intrusive in the latter.

At the commencement of the Cape period, *i.e.*, about Lower Devonian times, we may imagine that a great tract of land lay west and north of the position of the southern part of the Colony, for the materials comprising the Table Mountain series become somewhat coarser in those directions. That land furnished the enormous amount of sand, almost entirely of quartz grains, that now is the Table Mountain sandstone. This sandstone, which is roughly in the form of a broad belt about 500 miles long and 100 wide, was deposited in shallow water; denudation and earth movements have played a greater part in defining its present boundaries than original deposition. During its formation the floor must have been gradually sinking to allow of the accumulation of 5,000 feet of sediment which throughout bears evidence of deposition in shallow water. The shale bands may possibly indicate deeper water conditions, but not necessarily so; the striated pebbles in the Pakhuis shales and mudstone prove that glacial conditions prevailed for a time during that remote period, and that the ice which floated away from the shore carried with it these flattened and scratched pebbles, and dropped them in the mud being deposited at some distance from the shore. The fact that the series is thinner near Nieuwoudtville, at the extreme northern

end of the area occupied by the overlying Bokkeveld beds, than farther south, points to the subsidence which allowed of the accumulation of the sandstones having gradually proceeded northwards. This means that deposition began in the south earlier than in the north, so that the bottom of the series in the Bokkeveld Mountain area was formed later than the lowest beds in the Worcester or Ceres Divisions.

We cannot regard the Table Mountain series as a marine formation, it is probably a fluviatile deposit laid down near the source of origin of the materials composing it. The great thickness of sediment, and the evidence throughout that it was laid down in shallow water, prove that the area occupied by it underwent slow but steady depression, which continued for a long period after the peculiar conditions under which it was formed came to an end. This depression in the southern part of the Colony must have gone on till some time during the deposition of the Karoo formation, perhaps till late in the Beaufort period; it was brought to a close by the earth movements which produced the northern and western mountain ranges.

The northern limit of the depressed area cannot be defined, but it probably lay to the north of the thirtieth parallel.

During the Bokkeveld period the waters of a southern ocean that lay south and west of the Colony, and which spread at least as far as the position of the Falkland Islands and the South American Continent, gained access to the area where the Table Mountain series had been deposited. The presence of plant remains in

the Bokkeveld beds, along with the marine shells, shows that the land on which the plants grew was not far off. In the account of the Bokkeveld beds in chapter iv., the generally noticed increase of sandstone towards the north and west was explained on the supposition that the sediments were chiefly derived from land lying north and west of the districts where the Bokkeveld beds occur.

Marine conditions prevailed in the southern part of Africa till the middle of the Bokkeveld period, when open connection with the sea seems to have been cut off, for the muds, shales and sandstones of the upper Bokkeveld and the Witteberg series contain no other than plant remains. The cause and manner of this loss of connection with the ocean cannot be explained, as the evidence which might solve the problem lies below the waters of the Atlantic. The abundance of sandstones in the Witteberg beds, with their occasional white quartz pebbles, often in some respects closely resembling the Table Mountain sandstone, point to a recurrence of the conditions under which the latter was formed, though the frequence of thick shale bands proves that much of the finer grained sediment came to rest within the Colonial area in Witteberg times, while in the earlier period of the Table Mountain sandstone much less of the clays and silt, which must have been produced during the destruction of the rocks that furnished all the sand now forming the Table Mountain sandstone, remained in the same area.

Plants are the only fossils hitherto discovered in the Witteberg beds, and they are usually found in frag-

ments, bits of stems without leaves or other organs, and these fragments probably drifted far before becoming waterlogged. In the Eastern Province some beds are largely made up of compressed coaly-looking stems. Current bedding and ripple marks are very usual phenomena in the Witteberg series. In the south of the Colony the Witteberg period was brought to an end by the deposition of the green shales and mudstones of the Lower Dwyka beds, and no physical break or unconformity separates the two groups of rock. Deposition must have gone on continuously in the south of the Colony while the great change of climate took place that caused the glaciation of the country to the north of the Karroo.

While the deposition of sediments of various kinds went on uninterruptedly in the southern districts from the period of the Table Mountain series till far on in that of the Karroo formation, a rising of the floor began in the country north of the thirty-third parallel at some time during the Bokkeveld or Witteberg periods; for both in the west and east of the Colony north of that parallel of latitude an unconformity separates the lowest beds of the Dwyka series from the Cape formation. This rising of the land relatively to the water level must have taken place very gradually, as there is no strong discordance between the newer and older rocks. The Witteberg and Bokkeveld beds become gradually thinner and thinner northwards owing to the removal of a greater thickness of the beds in that direction during Pre-Dwyka times.

It is clear that in the country immediately north of

Karroo Poort, where the only beds usually met with in the southern districts that are missing are the Lower Dwyka shales, the exposure of the Witteberg series must have been of very short duration. Farther north their exposure to the agencies of denudation began at an earlier time, so that more and more of the Witteberg and Bokkeveld rocks were washed away before the Dwyka conglomerate was laid down upon the remnants. It is obvious that deposition and denudation on a large scale cannot go on at the same time in one and the same district, so that at Matjes Fontein on the Oorlog's Kloof River, where only the lowest of the Bokkeveld beds remain between the Dwyka conglomerate and the Table Mountain sandstone, and where some 2,000 feet of the Bokkeveld beds, if the series was ever so complete there as farther south, are missing, the removal of the rest of the group must have taken place during the formation of the Witteberg beds in the south. We can be certain, therefore, that the Witteberg beds were never deposited in the area just north of Matjes Fontein (Oorlog's Kloof River).

The northward extending depression, which allowed first the Table Mountain sandstone and then the marine beds of the Bokkeveld series to be deposited north of the thirty-third parallel, gave way to the opposite movement of upheaval at some time during the deposition of the upper part of the Bokkeveld or lower part of the Witteberg group.

It is possible that this change of direction in the vertical movement of the land was coincident with the beginning of the change in geographical conditions

which eventually brought about the cutting off of the Colonial area from the ocean in the middle of the Bokkeveld period.

The shore line at the commencement of the Dwyka period lay in an approximately east and west direction through the neighbourhood of Karroo Poort, and the shales and muds which were deposited near it are very like the more argillaceous sediments of the Witteberg series; they contain none of the fossil plants found in the latter, but a few plants of a similar nature to some of those found in the Ecca beds have been obtained from them. This shore line appears to have gradually crept northwards, but it did not gain much upon the land area to the north before the conditions set in that caused a general glaciation of that land.

We have seen in a previous chapter that there can be no doubt of the fact that South Africa north of the thirty-third parallel was in part, at least, covered with snow and ice, and that the Dwyka conglomerate is made of the mud, sand, pebbles and boulders derived from the glaciated country.

In the northern parts of the Colony, as well as in the eastern districts of the Transvaal and western portion of the Orange River Colony, the Dwyka conglomerate has to a certain extent the character of a morainal deposit. It lies upon a well-striated rock surface, and is mostly unbedded; it is a sandy mud or clay with large blocks and smaller fragments of various kinds of rock scattered through it. The occasional patches of conglomerate with a shaly matrix in the north can well be looked upon as having been formed in small glacial

lakes within the morainal area, *i.e.*, the area which belonged to the land rather than to the water.

Evidence of the movement of solid ice over a surface of earlier deposited conglomerate occurs as far south as Eland's Vley in the western Karroo. In Natal, 2° N. of that latitude, the conglomerate rests upon a glaciated surface of the Table Mountain series. It seems likely that the conglomerate to the south of Eland's Vley also rests upon a glaciated surface of the Bokkeveld or Witteberg beds, but this has not yet been proved.

The Dwyka conglomerate in the south is certainly much thicker on the average than it is north of the Karroo, and a gradual diminution in thickness has been noticed in passing northwards along the western border of that country from Karroo Poort to Calvinia. This is in perfect concord with the fact that the transgression, or gradual extension of the water area, and consequently of the shore line, took a northerly direction as shown by the increasing gap in the succession below the Dwyka series. There are no representatives of the Lower Dwyka shales in the north, and a considerable thickness of the southern conglomerate must have been deposited before the northern conglomerate began to be laid down. The few feet of conglomerate at Kimberley, for instance, were probably formed during the deposition of the uppermost part of the southern conglomerate.

The conglomerate in the south of the Colony was probably formed entirely under water; into the sand and mud there being deposited the pebbles and boulders, many of them well scratched, were dropped by the floating ice that drifted southwards from the shore.

No remains of animals or plants have been found in the Dwyka conglomerate, so the question of the nature of the water in which it was deposited is unsettled. The absence of marine shells is certainly presumptive evidence against the water having been a part of the ocean, for it is well known that a cold climate is by no means unfavourable to marine life at the present day. Many genera of molluscs and crustaceans are represented by unusually large species in arctic and antarctic regions. In any case the absence of fossils is difficult to explain, but considering also that only land or fresh water forms have been found in the beds underlying and overlying the conglomerate it is more probable that the water in the Dwyka basin was fresh than salt. The absence throughout the Karroo formation of deposits of rock salt, gypsum or other substances that accumulate in inland basins with no outlet is good evidence that the basin in which the rocks were formed was kept fresh by the continual escape of the water.

We may picture to ourselves a great inland water basin, with one or more outlets to the ocean towards the south, and covering what is now the southern part of the Cape Colony, at the commencement of the Dwyka period. The southern mountain ranges were not yet in existence, the rocks which afterwards built them up were lying horizontally below the surface of the lake. The nearest land lay to the north; the southern portion of it consisted of the then recently exposed Witteberg deposits, north of this area there were belts composed of the Bokkeveld and Table Mountain series, while still farther north lay a hilly

country composed of the Pre-Cape rocks. This country gradually became snow-clad, and glaciers and perhaps eventually a sheet of ice, of too great size to be called a glacier, slowly moved from various directions towards the lake, carrying with them mud, sand, pebbles and large blocks, derived from the surrounding land. Most of these materials reached the bottom of the great lake, but it is more than likely that parts of the unbedded conglomerate in Prieska and elsewhere in the northern districts are the remains of moraines that lay between the ice and the floor in the lower parts of the land, or that were piled up in front of the ice. Meanwhile the floor of the lake sank, so that at least 1,000 feet of conglomerate accumulated over the southern part of the Colony; the water stretched farther and farther north as time went on, so that at the close of the glacial period shales were being deposited at least as far north as the Kalahari Desert.

The thousand feet of mud and stones which must extend over thousands of square miles under the southern part of the Karroo, and formerly spread as far south as Worcester, and very probably farther than the present southern limit of the continent, represent the products of denudation of a large tract of country during a long time. The wide distribution of the striated blocks and pebbles, which are found wherever the outcrops are sufficiently good to allow one to obtain the contained boulders, shows that the glaciation was no merely local phenomenon, to be likened to the very limited snow and ice covered areas within tropical Africa at the present day, but that it

was a wide-spread glaciation, extending over a large part of the continent north of the Karroo area. The source of the Dwyka boulders has been described in an earlier chapter, and we found that though the source of many is at present unknown, yet a sufficient number have been recognised as having come from the Pre-Cape rocks north of the Karroo to show that the main source of the Dwyka series, so far as the Colonial area is concerned, lay to the north; the evidence hitherto noticed of the movement of the ice in the northern districts is to the same effect, *i.e.*, that the ice moved southwards from those districts. Whether land to the south also contributed ice-borne debris is unknown, but at least at a certain stage of the period another source lay to the west, as shown by the striated pavements in the western Karroo.

The evidence for the glacial origin of the boulder beds at the base of the Gondwana system, and in the lower part of the beds containing the *Glossopteris* flora in Australia, does not seem to one who has not seen it himself to be so strong as that for the glacial origin of the Dwyka conglomerate and the scratched surfaces below it in the northern parts of Cape Colony, but the testimony of so many geologists who have seen the Indian and Australian rocks, and who are agreed that the striated boulders found in them owe their form to glacial action and their position to carriage by ice, cannot easily be set aside. The very fact of the occurrence of such phenomena at the base of the beds containing the *Glossopteris* flora in those far distant lands, in a precisely analogous position to that

of the Dwyka conglomerate in South Africa, is itself presumptive evidence that all the peculiar characteristics had a common cause, and no agency save glacial conditions can be put forward to explain the appearances in the Dwyka series described in a previous chapter. The explanation of this glaciation is not yet clear. Penck has examined the supposition of an altered position of the earth's axis with one pole in the middle of the Indian Ocean and the other in North-West Mexico, but the recorded direction of the movement of the ice in South Africa, India and Australia are not in agreement with such a position of the South Pole, and there is no evidence of corresponding glacial conditions in the American Continent; in addition to this astronomers seem to be agreed that such a change in position of the axis of rotation (some 66°) is quite out of the question, at any rate since the birth of the moon, which would take us back to a period far more ancient than the one we are now dealing with.

It is difficult to find a sufficient cause of the glaciation in the supposed existence of a tract of very high mountainous country to the north of Cape Colony, for the ice certainly reached the shores of the water in which the southern conglomerate was laid down, and unless we have good reason to believe that this water-level was at a great height above sea-level, which is not probable, the ice must have passed into the Karroo water at a level that was not very much above that of the sea. In addition to the objection to the existence of very high land north of Cape Colony, the widespread distribution of the boulder beds in Africa, India and

Australia, demands, as Penck points out in the paper referred to above, a correspondingly widespread cause, and the existence of a greatly elevated country of such extent is at least improbable. Whatever may have been the cause of the cold climate, the fact of its having prevailed is as certain to the mind of a geologist who has seen the Dwyka conglomerate, and the underlying striated floors in the north of the Colony, as the former presence of man is to the person who picks up potsherds on a sandhill or sees figures of men and beasts rudely painted on the wall of a cave.

Although it can hardly be maintained that the fossil evidence in South Africa, India and Australia is as yet sufficiently strong to prove the contemporaneity of the boulder beds in the three continents, for that would require much longer series of fossiliferous strata in those localities than have been found, yet so far as the facts go they undoubtedly give us very good grounds for assuming that the boulder beds were formed at about the same period. There seems to have been in late Palæozoic times a great mass of land, whose boundaries are very imperfectly known, but which included part of Africa to the north of the Colony, a part of Australia, and a part of India, and which stretched across the Indian Ocean; on this land glacial conditions prevailed during a certain period. The flora and fauna of the land during and subsequent to the cold period was quite different to those which spread over the European and North American areas at the same time, for only a very few of the typical Karroo and Gondwana forms have been found in those regions. Some of the products of

the denudation of this ancient continent—Gondwanaland—accumulated in great fresh water lakes, of which the Karroo area of South Africa is one. It is useless at the present time attempting to fill in the details of the history of the sediments derived from Gondwanaland; to discover, for instance, how many fresh water basins existed, and to what extent they communicated with each other and with the ocean. In South Africa all the fossils yet found in these sediments lived upon land or were fresh-water forms, no distinctly marine animals are amongst them. In New South Wales, on the other hand, a striated boulder bed has been found in strata containing marine fossils of Upper Carboniferous types. Whether any evidence of an encroachment of the ocean upon the Karroo lake exists in South Africa remains to be discovered.

On the African portion of Gondwanaland at first grew *Glossopteris* and its associates mentioned on a previous page; and soon there appeared the remarkable reptiles, of which *Pareiasaurus* was one of the earlier and larger forms. *Pareiasaurus* and *Dicynodon* were certainly vegetable feeders, but carnivorous beasts were by no means wanting; a glance at the formidable teeth in such an animal as *Titanosuchus* is sufficient to convince any one that their possessors lived upon their fellows and did not graze on the *Glossopteris* and other plants that covered the ground. The bones now found in the Karroo belonged to bodies that were carried down by rivers or drifted from the shores of the lake.

The Karroo area, and with it probably the whole of the folded belt, must have sunk to allow the accumula-

tion of the thousands of feet of shallow water deposits that we see in the Karroo formation. Occasionally perhaps wide stretches of mud or sand lay exposed for a time above the water, to be submerged again and buried under similar sediment. Such flat islands can now be recognised where the slight unconformities in the Ecca and Beaufort series mentioned in chapter v. are found.

The duration of this slow depression was unequal in different parts of the Colony; it was less along the southern and south-western area, where the Cape formation was thickest, than to the north. Probably while the upper part of the Beaufort series was being laid down, the folding began that eventually produced the great southern mountains. It is not yet known exactly when this process began, or when it reached its maximum, but there is little doubt that it was in progress during the later portion of the Karroo period. The numberless places along the southern edge of the Karroo where the lower Karroo beds can be seen resting conformably upon and involved in the folds that affect the Witteberg, Bokkeveld and Table Mountain series as well as the occurrence of the Dwyka and Ecca beds at Worcester, and the outliers on the northern edge and in the heart of the folded belt, prove conclusively that the main part of the disturbances took place after the Ecca beds were deposited. The Uitenhage beds, lying comparatively undisturbed upon the contorted strata belonging to the Cape formation, and in places upon the Pre-Cape rocks, give the clearest evidence for believing not only that the earth-movements

responsible for the mountain chains had done their work before these beds were formed, but also that a tremendous amount of rock had been removed from the folded belt before that time. We have seen in earlier chapters that the Dwyka and Ecca beds belong to the later part of the Palæozoic era, to the period for convenience called Permo-Carboniferous, and that the Uitenhage beds are of early Cretaceous age. It was during the interval between those roughly defined periods that the mountain building in Cape Colony went on. In other countries this interval is represented by the Triassic and Jurassic systems, but in South Africa the only beds that can be referred to either of these are the Beaufort and Stormberg series, and they belong to the Trias rather than to the later stage.

The southern folding seems to have been produced by a thrust from the south towards the north, for the folds, where not symmetrical, tend to turn over towards the north. The minor ranges, such as the Caledon Mountain, Warm Water Berg and Touw's Berg are symmetrical, both limbs of the anticlines are equally inclined, and the same is the case with Anysberg, the western end of the Table Mountain sandstone ridge of the Zwartebergen; but in the high ranges, the main portion of the Zwartebergen and the Langebergen, the folds lean over northwards, so that both limbs of any one fold dip southwards. This structure seems to indicate that the region of the Great Karroo acted as an immovable block against which the strata of the folded belt were crumpled and turned over. The overthrust faults in the Dwyka series near Laingsburg are

also directed towards the north, as though the pressure had to be relieved by the sliding of blocks of beds over the fractured edges of the next block to the north. It is on the south flanks of the most crumpled ranges that the great strike faults of Worcester and the Cango occur, and their downthrows are very considerable, reaching at least 10,000 feet at Worcester. The western folds are not nearly so intense as the southern, and may have begun at an earlier date. The easternmost of these anticlines, that which forms the Cederbergen, is also the greatest, and it is fairly symmetrical; no considerable folds lie parallel to it on the east; to the west, however, there are several parallel folds decreasing rapidly in amplitude towards the coast.

The neighbourhood of Worcester, where the Uitenhage conglomerates lie upon the Ecca beds and the Pre-Cape rocks on either side of the great fault, affords a grand object-lesson in denudation. To the north of the fault the conglomerates lie directly upon the Malmesbury beds; to the south, part of the Ecca, the Dwyka series and the whole of the Cape formation intervene between the two. The thickness of the intervening rock is not less than 10,000 feet. Between the fault and the mountains to the north of it over 10,000 feet of rock must have been removed during the interval (Jura-Trias) spoken of above. Nowhere else in the Colony is the evidence of this denudation so clear as at Worcester, but with it before us we can believe that a similar amount of rock was removed from the Pre-Cape areas of Mossel Bay and the Cango, which are now partly overlain by the Uitenhage conglomerates. It must not be forgotten,

however, that the Worcester conglomerates may be somewhat later in age than the similar rocks at Enon and Uitenhage, but the difference is certainly small.

When describing the dolerite intrusions of the Karroo we noticed that they seem to have avoided the folded belt; they occur to the north of it and on its extreme limits, where the intensity of folding is much less than in the major portion of the belt; we noticed also that this peculiarity in the distribution of the dolerite pointed to the folds having been in existence or in progress when the dolerite was intruded. Now the dolerite is probably of late Stormberg age, for the points of resemblance to the dolerites which are found in the volcanic beds are so numerous, and at the same time of more importance than the differences between them, that it seems that both the general mass of dolerites in the central and eastern parts of the Colony and the distinctly volcanic rocks belong to one series and reached their present position at about the same time, the end of the Stormberg period. The only other direct evidence of the age of the dolerites at present known is the occurrence of the rock as boulders in the Embotyi conglomerates, which we must regard as of Cretaceous age but probably younger than the Uitenhage beds. This fixes a later limit to the age of the intrusions. If the Embotyi beds should eventually prove to be of Uitenhage age the limit will be correspondingly set back. But the first argument, concerning the connection of the dolerites and volcanic beds, certainly supports the assumption that the intrusions took place at the close of the Stormberg period, and this helps us to determine

the date of the folding in the southern mountainous region.

Whether closer limits can be set to the period of folding than the Ecca and Uitenhage periods remains to be found out in the future. It is possible that the unconformity near Aberdeen, between the Ecca and Beaufort beds, described by the late Professor A. H. Green may be more than a local phenomenon, and if so it may lend material aid to the solution of the question, but so far as our knowledge of other parts of the Colony goes there is no physical break at that horizon. It may be that all traces of the unconformity which probably existed within the Karroo formation somewhere to the south of the main Colonial watershed have been removed by denudation. The uprising of the folded belt exposed the southern parts of the Colony to the air and to all the destructive agencies, such as change of temperature, wind, rain and streams, that this entailed. There were then formed the great longitudinal depressions between the Zwartebergen and Langebergen, and the other more or less east and west ranges in the south. To this period probably belongs also the first rough shaping of the western coastal districts, the removal of the upper parts of the Cape formation from Malmesbury, Piquetberg and neighbouring districts, and the Olifant's River Valley (Clanwilliam). While this was going on the upper parts of the Karroo formation were being laid down in the north-east, possibly also far to the north and north-west of the existing boundary of the Stormberg series. The time represented by these rocks witnessed

a great change in the inhabitants of the land round the Karroo lake. *Glossopteris* and many of its fellow plants of the earlier period died out and were replaced by a new vegetation, of which *Thinnfeldia, Tæniopteris, Baiera* and *Callipteridium* are the best-known members. The fauna likewise changed, *Pareiasaurus*, *Dicynodon* and their allies disappeared to make way for more highly organised reptiles.

Below the Molteno beds there is no direct evidence of a diminution in size of the water basin in which the Karoo formation was deposited, but the coarse sandstones in the Molteno beds and the overlying strata, the coal seams and the occasional thin conglomerates in the Molteno beds all point to the proximity of land during their deposition. It is not yet possible to define the position of the neighbouring land, but it is probable that part of it lay to the south-east of the Drakensberg ridge.[1]

The present main watershed of the Colony was probably produced during the Stormberg period by the rising of a low tract of country from the Karroo area, trending in a north-easterly direction. The water which fell on this land drained off towards the north and south, giving rise to the chief rivers draining what are now the Great and Upper Karroos. It is as yet difficult to account for the appearance of this land, for there is now no sign of an anticlinal ridge corresponding in direction with the main watershed. On the other hand, the structure of that area is that of a very gentle syncline. It is possible

[1] Schwarz (03).

that the synclinal structure was given to the country at a somewhat later period. The intrusion of the dolerite sheets, which on the average reach a thickness of perhaps 1,000 feet over a wide area in the central districts of the Colony, must have produced some effect at the surface, and may have been the cause of the emergence of the watershed.[1] The varying position of the base of the Stormberg volcanic series proves that the Cave sandstone was subjected to denudation before the volcanic outbursts commenced, but there is also evidence in the interbedding of the two groups of rock that the denudation was local, and that the Cave sandstone continued to be formed after the earliest activity of the volcanoes. The outpouring of the immense thickness of lava, described in a previous chapter, put a stop to the deposition of ordinary sediments, and the conditions under which sandstones, shales and other sediments are formed seem never to have prevailed again in the interior of the Colony. The present state of our knowledge of the volcanic series is too imperfect to allow a satisfactory statement of the effects due to the volcanic episode to be made; but it may be taken as certain that one result was to add a great volcanic pile to the north-eastern end of the newly emerged land.

There seems no escape from the conclusion that denudation has proceeded uninterruptedly from the close of the Stormberg period (Rhætic) to the present day in the interior of the Colony. No deposits of later age,

[1] For discussions on the origin of the watershed see Schwarz, *The Volcanoes of Griqualand East* (03), and Rogers, *The Geological History of the Gouritz River System* (03).

other than river gravels, alluvium and sand, have been found north of the folded belt.

During the Jurassic period the valleys in the folded belt were greatly enlarged and deepened, so that the Pre-Cape rocks became exposed in several areas south of the Zwartebergen, where the chief rivers appear to have had east and west courses. The rivers running south from the main Colonial watershed have left no trace of their passage through the mountain ranges in pre-Uitenhage times, though the valleys excavated in the folded belt before the deposition of the Uitenhage beds were deeper, relatively to the ranges, than the modern ones in the same districts. The water flowing southwards from the main watershed probably drained away to the sea in an easterly direction. This great period of denudation received a partial check in early Cretaceous times, so that the longitudinal valleys in the folded belt became filled with conglomerates, sandstones and shales, now represented by the outliers of Uitenhage beds described in chapter viii. The cause of this may have been twofold, first, the sinking of the land, and, secondly, the coming in of a drier climate. That the former cause played an important part is evident from the fact that the marine Sunday's River beds occupy an old valley between Port Elizabeth and the Zuurbergen; and the second of the two causes is indicated by the nature of much of the conglomerates and sands, the Enon type of the Uitenhage beds. It is not improbable that the Uitenhage beds eventually covered the whole of the folded belt, with the exception of parts of the mountain ranges; there is reason to believe that in

places the lower passes in those ranges were buried under the gravels and other rocks of the Uitenhage series. As we saw in chapter viii., there is no evidence to show how far west of the Zwartkops Valley the marine beds extended.

Towards the end of the Uitenhage period we may suppose that a low belt of land stretched north-east through the middle of the Colony, ending in a great mass of volcanic rocks, and that to the south of this land there were ridges of mountainous ground projecting above a shallow sea, or through gravel and sand deposited by local streams in a flat country only partially under water. Whether these sediments, in whatever way they were formed, spread north of the Zwartebergen will perhaps never be known, but it is possible that they did so, and that the streams flowing southwards from the main watershed eventually delivered their loads of silt into the same area instead of reaching the open sea to the south-east. It appears to be probable, however, that the rivers ran southwards across the newly deposited Uitenhage beds when the uplift occurred which put an end to the deposition of those beds in the folded belt.

The course of events north of the watershed, in the country drained by the Orange River, is much more difficult to decipher, and at present too little is known of the details of its geology to allow one to attempt the task. The mountain building which produced the southern and western ranges did not affect the north of the Colony, and no equivalents of the Uitenhage beds are known to exist in that region. Probably the

Orange River commenced its work at the same time as the streams flowing south from the main watershed.

At some time after the deposition of the Uitenhage beds earth-movements took place in their area, and the effects of these are seen in the inclination of the Uitenhage strata, and in the faults that traverse them. These movements had partly the same direction as the earlier ones that produced the mountains, but there is no evidence yet discovered that proves the new movements to have always followed the older very closely. For example, the Worcester fault, and the southern boundary fault of the Cango district do not appreciably affect the Uitenhage beds, though the latter have slight dips in the neighbourhood of those great dislocations. Along parts of the faults the Uitenhage beds lie comparatively undisturbed on the old surface on both sides of the fault without any indication of faulting along the same line. In Uniondale and Willowmore, on the contrary, conglomerates of the Enon type have been let down against the Cape formation along faults that are parallel with the strike of the folds produced in the latter formation in Pre-Uitenhage times; the downthrow is always to the south, as in the case of the older faults. The effect of the faulting and folding of the Uitenhage beds must have been to accentuate former longitudinal valleys, if they were in existence, or to give rise to them. The extent to which the dislocations were carried was, however, insufficient to disarrange the already established southward courses of the rivers draining the Karroo. These rivers gradually cut down their valleys through the Uitenhage beds, so that they reached

the underlying sharply folded Cape formation, a process that still continues; but, as we shall see, there have been periods of diminished downward erosion during which the rivers widened their valleys and cut extensive plains instead of deepening their channels. The river systems south of the main watershed thus developed on a country whose structure has no direct relationship to the origin of the main rivers, and the deep gorges of the transverse streams, such as the Gamka and Gouritz, were sawn through by the rivers cutting their way downwards through soft and hard rocks alike as they were exposed. It is not improbable that the earth-movements of post-Uitenhage age deepened the depression between the Zwartebergen and Langebergen, but the movements were greater in some places than others, and were not sufficiently regular in direction and extent to deflect the chief transverse stream into valleys parallel to the mountain ranges.

In the marine beds of the Uitenhage series we have the inshore deposits of an ocean that stretched from India to South Africa, but its general form is very imperfectly known. So far as South Africa is concerned that ocean probably only touched the country and never spread over what is now the interior of the Colony. The next inroad of the open sea is recorded in the Umzamba beds of the south-east coast. The fossils in these rocks are most closely related to Indian forms, and indicate that the beds were laid down at a later stage of the Cretaceous period than the Sunday's River beds. The fact that the Umzamba and the Embotyi

beds are faulted down against the Table Mountain series shows that they once extended farther inland than their remnants are found to-day, but as they are distinctly in-shore deposits, as opposed to those formed under deep-sea conditions, they probably never stretched far inland beyond their outcrops in Pondoland. We have as yet no sign of a passage from the Uitenhage into the Umzamba series, but negative evidence on such a point is worthless under the circumstances; we cannot, therefore, say whether the ocean retreated and returned, or whether a conformable group of beds, from the Uitenhage to the Umzamba series, once existed in or near the south-east limit of the Colony.

The boundary faults of the Pondoland Cretaceous rocks were evidently formed in post-Cretaceous times, and they appear to have no connection with the earth-movements that affected the Uitenhage beds of the west. In direction (north-east) they agree more closely with the line of volcanic vents in the Drakensberg, so far as the latter is known, than with the nearly east and west, or east-south-east flexures into which the Uitenhage beds were thrown. The Pondoland faults are approximately parallel to the coast, and were probably closely connected with the formation of that part of the South African coast line. So far as our information carries us at present this is the only part of the Colonial coast defined by faults.

At some time subsequently to the deposition of the Uitenhage beds volcanic explosions took place at various spots from Spiegel River in the south to Griqualand West in the north, and the chief products of this third

phase[1] of volcanic activity in the Colony were melilite-basalts and peculiar breccias; the latter include the blue-ground of the Kimberley and other pipes. These volcanoes seem to be distributed sporadically without any relationship to the earlier established structural lines in the Colony, and they do not appear to have thrown out any considerable quantity of lavas or ashes.

Returning now to the southern rivers, which we described as cutting down their valleys through the Uitenhage beds to the underlying rocks, we must endeavour to trace the events which have taken place since they began to cut through the partially buried mountain ranges. Throughout the southern districts of the Colony there is abundant evidence bearing on this portion of its history; this evidence is given by the gravel and alluvial terraces lying high above the bed of the modern rivers. The absence of contoured maps and a close knowledge of the height of the terraces greatly increase the difficulties of the problem, and it would be useless to attempt more than a sketch of the main conclusions to be derived from the facts at present known. The oldest, or highest, well-developed terraces lie over 1,000 feet above the modern river beds, and there may be still more elevated terraces. When the rivers from the Karroo flowed at levels about 1,000 feet higher than at present their downward cutting powers were checked, and they, together with their tributaries, planed off the country to a more or less common level, producing a

[1] The other two gave rise to (1) the Pre-Cape volcanic rocks of Prieska and Griqualand West, and (2) the Stormberg volcanic rocks. The former, however, may represent more than one period of activity.

slightly undulating plain, from which rose the long mountain ranges and the smaller anticlines, such as the Caledon Mountain and Warm Water Berg. The distinct terraces forming conspicuous features on the slopes of the Langebergen and Zwartebergen, where the hard folded quartzites are cut to a nearly flat surface, were made during this period of lateral erosion. The cause was widespread, for we find its effects from the Transkei to the Zwart Ruggens west of the Karroo. An obvious possible reason for the cutting of these terraces is that the sea stood higher relatively to the land than is the case to-day, but whether the rivers had previously cut their channels down to sea level and so were unable to further deepen their valleys, or whether the country as a whole sank and therefore checked the deepening of the valleys, is not certain. The former is perhaps the more likely, for no filled-up channels near the coast have been found, and they might be expected had the valleys been eroded to a greater depth than could be maintained under the new conditions. Local plains might well have been formed behind the larger blocks of mountains, just as we see wide alluvial flats in the course of the Buffel's River behind the Leeuw Kloof Poort and the plain cut by the Olifant's River before entering its gorge in the Gamka Hills. The terraces on the flanks of the mountains, with the outlying table-shaped fragments of the plains that formerly connected them, are so extensively developed, both to the north and south of the Zwartebergen, that they cannot be explained by a local cause like that which is sufficient to account for the alluvial flats of the Olifant's River. It is probable

that the high-level plateau in the country south of the Langebergen was formed at the same time as the terraces we have been discussing, although it lies at a lower level, for then, as now, the rivers must have had a fall towards the coast, and each gorge through the great ranges was perhaps more steeply graded than the valley-bottom above or below it.

The rising of the country relatively to the sea-level renewed the downward cutting powers of the rivers and restricted the stream erosion within narrow limits, so that great parts of the old plains were permanently abandoned. The change in the drainage system thus effected was considerable in certain areas; the watershed between the Olifant's and Baviaan's Kloof Rivers now lies on a high level gravel plateau, and before the platform was cut the watershed may have been far from its present position.

At the present time the Dwyka and Gamka traverse the Zwartebergen together by the Gamka Poort, and at a point thirty miles below that gorge the Buffel's River joins them to form the Gouritz River; to do this the Buffel's River turns sharply to the east, away from what one would suppose its proper course to have been; the depression on the crest of the Langebergen, called Garcia's Pass, lies directly in the supposed normal course of the river, so it is not unlikely that its upper part was captured by a western tributary of the Gouritz. This must, however, have happened before the high-level plain was cut, for the summit of Garcia's Pass lies higher than the terrace on the north flank of the Langebergen.

There are other terraces at lower levels than those mentioned above, but to bring all these into order and to place them in chronological sequence is at present impossible on account of the lack of detailed information as to their relative heights and distribution.

The raised beaches and the limestone formed from sand dunes now lying at considerable heights above the shore and at some distance inland, must belong to one of the periods of plain-cutting; there is as yet insufficient evidence to correlate these phenomena definitely, but it may well be that the higher shore terraces, such as that covered by the marine gravels of the Zwartkops Heights, and the old beach underlying the limestone of Cape Infanta, were removed out of reach of the waves when the inland plateaux, 1,000 feet above the modern river beds, were elevated.

The numerous S-curves of the southern river valleys with precipitous sides, often several hundred feet high, are relics of the time when the streams meandered slowly across nearly flat plains; on the fall of the streams being increased by the rise of the land their downward cutting power was renewed and they deepened the valleys in which they flowed, so that in many cases the S-bends were retained and deepened to the extent we now see. One of the most remarkable of these is the S-shaped gorge in the Klein Zwartberg occupied by the Buffel's River; another has been cut by the Gamka between the Roode Berg and the Pogha Hills; from the Eastern Province the extremely sinuous and deep valleys of the Great Fish, Kei and Bashee Rivers are analogous examples.

Hitherto we have only given the evidence for elevation of the land relatively to the water in connection with the superficial deposits. There is, however, some indication of recent depression; the great depths of the estuarine shelly sands and muds near the mouths of some of the rivers, especially the Zwartkops and Buffalo Rivers which are the only ones that have been explored in this sense, may be due to depression. On the west coast, Saldanha Bay, an almost land-locked basin in granite, appears to be a drowned valley. There is no well-defined valley entering the bay, though the thick superficial sandy deposits that stretch south-east of the bay may conceal an old river channel. At many places in Saldanha Bay the dune limestone containing the remains of land snails passes below sea-level, as is also the case near Struys Point and the mouth of the Duiven Hoeks River on the south coast. At Paternoster, north of Saldanha Bay, a well sunk at a spot about twenty feet above sea-level revealed the presence of ninety feet of sandy limestone and sand containing land shells, tortoise bones, and broken marine shells, evidently an accumulation formed on the land behind the beach, and not below tide-level. These facts all point to a recent depression.

Throughout this account of the changes of level which have affected the Colony the expressions "uplift" and "depression," or equivalent terms have been used. It is, however, one of the obscure problems of geology to find out whether apparent uplifts and depressions are due to the movement of the land or to that of the surrounding ocean. Where the strata concerned are bent,

the changes must at least in part be due to the movements of the rocky crust of the earth; but where a widespread alteration of relative level has taken place, such as that which caused the abandonment of the high-level plateaux by the streams which once flowed across them, the question is not easy to decide. Should it be found that terraces or raised beaches that were once on the same level are now at different heights above the sea, then earth movements must have played a part in bringing about the change. The evidence to decide even this detail with regard to the Cape terraces and beaches has not yet been collected, and it is not such a simple matter as it may appear. The recent deposits as a whole are remarkably deficient in organic remains, though up to the present time they have not been systematically searched; and it is only possible to determine the contemporaneity of detached portions of terraces and beaches by a study of their fossils. A thorough investigation of the facts bearing upon the past changes in level in the Colony will add much to the materials for the decision of the problem.

CHAPTER XII.

NOTES ON THE GEOLOGY OF SOME OF THE RAILWAY LINES.

In this chapter it is proposed to point out the chief points of interest to be seen along the railway lines, or rather those portions of them about which I have definite information.

The Western Main Line to the Orange River.

From Cape Town the line passes through the Cape Flats as far as Durban Road Station. On either side of the line blown sands overlying ironstone clays and sands stretch for several miles. As a result of the systematic planting pursued by the Government the drifting sands in this area have been checked, and wattle thickets cover what used to be one of the heaviest parts of the country for travellers before the railway was made. The only outcrops of hard rock in the Cape Flats are the surface-quartzites, patches of which lie close to the line about ten miles from Cape Town. At Durban Road the line enters a country which is still flat, but the Malmesbury beds and the intrusive granite lie close under the surface soil. To the north-west are the Tyger Berg and the hills near Durbanville formed of slaty and quartzitic beds be-

longing to the Malmesbury group; to the south-east lie Kañon Kop and Bottelary, composed of granite, while farther off rise the great Table Mountain sandstone mountains of Stellenbosch and Hottentot's Holland. Between Mulder's Vley and Klapmuts the line traverses a north-westerly fault, on the south-west side of which outliers of the Table Mountain series have been let down against the Malmesbury beds and form Klapmuts Hill and Joosten Berg.

At Paarl the railway turns northwards and runs parallel to the Klein Drakensteins (Table Mountain sandstone) and the ranges north of them, down the valley of the Berg River, with the great granite Mountains of Paarl and Paarde Berg to the west. The isolated mountain lying about eight miles west of the railway between Hermon and Porterville Road is Riebeek's Kasteel, an outlier of the Table Mountain sandstone. The mountain ridge extending north from the Drakensteins is part of the western limit of the folded belt. The Cape formation east of the range is considerably folded and faulted, but to the west it is but slightly folded and over large areas it has been removed by denudation. The country so far described belongs to the Pre-Cape region. Just beyond Porterville Road the line crosses the mountains by the New Kloof and enters the great depression drained by the Klein Berg and Breede Rivers, and in which lie the agricultural districts of Tulbagh and Worcester. The watershed between the two rivers is a scarcely noticable rise near Ceres Road Station, but to the north the water flows through the New Kloof, while to the south the Breede

River, after a long journey through comparatively flat ground, traverses a high range of Witteberg hills on its way to the sea at Port Beaufort. East of the New Kloof the line runs south to Worcester, where it turns north-east to traverse the Hex River Mountains; for some thirty-five miles it lies between two ranges of mountains, the Witzenbergen and their southern continuations on the east, and the Drakenstein Slang Hoek mass on the west. The Table Mountain sandstone of both these is seen to lie apparently horizontally when viewed from the railway, and obviously once stretched across the valley, covering the Malmesbury beds forming the low ground. When these mountains are examined closely, however, the strata are found to dip at various angles away from the valley, and to present their edges towards it. South of the Breede River Station the sandstone to the south-west of the line takes on a different dip, towards the valley instead of away from it. This becomes more and more marked towards the corner of the great mountain mass at Brand Vley, and is one of the phenomena connected with the Worcester fault. The wide area of gravels along the Breede River and the Uitenhage conglomerates (Enon type) to the east conceal large portions of the underlying Malmesbury, Cape and Karroo formations near the fault. The railway passes over the fault twice, once about four miles west of Worcester Station and again two miles north-east of the station. It makes no feature at the surface, and its presence is only indicated along this part of its course by outcrops of Ecca beds in contact with the Malmesbury series. From Worcester some

interesting excursions can be made. To the south the greater part of the succession from the Table Mountain sandstone to the Ecca beds is well exposed east and north-east of the mountain between Brand Vley and Stettin's Berg; at Waai Kloof, twelve miles east from the town, the unconformable junction of the Table Mountain sandstone with the ottrelite schists and quartzites of the Malmesbury group can be seen; while to the north there are numerous exposures of slates, schists, together with gneiss, and other igneous rocks of Pre-Cape age. The railway crosses the second range of mountains by the Hex River Valley, which is situated just to the east of the bend or angle formed by the meeting of the north and east trending ranges. On emerging from the Poort the Hex River Mountains lie to the north and are admirably displayed to a traveller by train. The railway is carried up the left side of the valley, along the V-shaped synclinal area of Bokkeveld beds. Between De Doorns and Touw's River some of the richest localities for Bokkeveld fossils are passed, and for the greater part of the way the line is laid on the lower divisions of the Bokkeveld beds which alone contain marine fossils. The best localities for searching for fossils are near De Doorns, the quarries at Tunnel Siding, and Klein Straat. A short distance beyond Klein Straat a fault with downthrow to the north is crossed; it bounds the northern face of the eastern spur of the Hex River Mountains, and along it the Witteberg beds are brought down against the Table Mountain sandstone. Near Klein Straat an isolated anticline of Table Mountain sand-

stone, Baviaan's Berg can be seen to the south; it rises from a rather flat country, the Touw's Vlakte, cut out of Bokkeveld beds. The Witteberg series forms the high hills to the north and east. Some of the remarkably sharp folds in the Witteberg beds can be seen from the railway three miles on the up side of Touw's River Station. The prominent bands of rock are quartzites, and the intervening shales, darker in colour than the quartzites, have weathered away more rapidly, leaving the quartzites standing out on the sides of the hills. Six miles on the down side of Touw's River the line enters the synclinal outlier of Dwyka conglomerate of Quarrie Kloof. The Witteberg quartzites dip under the outlier and form the bare precipitous hills to the north and south; the conglomerate crops out near the railway line in irregular lumpy masses showing the rough cleavage or slab-structure which is characteristic of that rock along the south of the Karroo. After journeying some ten miles on the conglomerate we cross to the Witteberg beds again, but this formation is finally left near Pieter Meintjes, where we enter the main area of the Dwyka series. The dark cliffs to the north of the line between this station and Matjes Fontein show the rather feebly developed stratification planes in the conglomerate, and the kopjes nearer the railway are good examples of the usual aspect of the conglomerate south of the Karroo. The included boulders are often large enough to be seen from the passing train, and the slab-structure producing the characteristic pillow-form of the exposed surfaces is prominent. About half a mile south of the line at Matjes Fontein there

are three white quartzite kopjes formed by lenticular deposits of that rock within the conglomerate. Matjes Fontein is a good centre for an examination of the conglomerate. Numerous striated boulders may be obtained from the rock in the hills north of the station, where good exposures are numberless; the variety of rocks forming the boulders is also very great in this locality. To the east-north-east of the village the succession from the conglomerate to the bottom of the Ecca series is exposed on the steep sides of a high hill. South of Matjes Fontein and for some twelve miles on the way to Laingsburg the steep, bare dip-slopes of the uppermost quartzites of the Witteberg formation bound the view; at places high up on these mountains (the Wittebergen) the strata appear to be lying horizontally upon the steeply dipping beds of the lower slopes, an appearance due to the sharp bending of the beds and the removal of the outer part of the bend by denudation; on ascending the range from Matjes Fontein its structure becomes obvious. The line leaves the Dwyka series about nine miles from Laingsburg and enters the great area of Ecca beds, the sandstones and shales of which are exposed in the railway cuttings and on the bare hills on either side of the line. Near Laingsburg the most prominent ranges of hills are formed by the middle portion of the Ecca series, called the Laingsburg beds. Just before reaching the station the line crosses one of the rivers which drain the Karroo region, the Buffel's River from the Moordenaar's Karroo. This river, which usually has only isolated pools of water in its bed, passes through the Zwartebergen by means of a great gorge

about six miles in length with vertical sides. It is well worth making a journey from Laingsburg to within the great poort in order to see it. Laingsburg is a convenient place for excursions to the Zwartebergen and the Dwyka and Ecca beds. A walk from the village up the Buffel's River towards the Moordenaar's Karroo illustrates admirably the passage from the folded belt to the little-disturbed interior basin; the strata are thrown into extremely sharp folds and are overthrust towards the north[1] at places near the village; farther up the river, which traverses the beds at right angles to their strike, the folds die out rapidly and at a distance of about eight miles the strata lie nearly horizontally, a condition that is maintained for hundreds of miles northwards, with the exception of a few small monoclinal folds south of the Komsberg.

From Laingsburg the train passes along the northernmost portion of the folded belt for some forty miles, but before Prince Albert Road is reached the folds are no longer seen and the strata everywhere lie at very low angles. The Great Karroo is entered at Laingsburg; the almost bare hills of shale and thin sandstones and the scanty vegetation, consisting of small bushes which only look green after good rains, are characteristic of thousands of square miles from Karroo Poort in the west to Somerset East, and from the main watershed

[1] About one and a half miles from the village on the road to Zout Kloof there is a clearly exposed section showing the chert band repeated three times by overthrust faults, and near by the lower part of the Upper Dwyka shales are thrust over the higher portion containing the white band.

on the north to the Zwartebergen in the south. The thorn trees along the river beds are the only green things usually visible from the train in this area. The various forms of kopjes due to the action of rain and wind on thin sandstones and shales dipping at different angles are well displayed along the line from Laingsburg to Beaufort West. On the up side of Prince Albert Road the ridge, or hog back, type is the usual one, owing to the inclined position of the strata, but when we reach the almost horizontal beds, low table-shaped hills with steep sides are the predominating forms. The table-shape is due entirely to the weather acting on horizontal beds, the thin but hard sandstones check the destructive process and give rise to flat caps to the hills. These flat-topped hills are very different in nature from the somewhat similarly shaped hills seen along the line from Swellendam to Riversdale ; the latter are parts of a stream-cut plain isolated by the renewed activity of the streams owing to the elevation of the whole country. Southwards from the railway the great range of the Zwartebergen towers 5,000 feet above the lower portions of the Karroo. The various ranges of foothills can be distinguished from certain points on the line on favourable days. One great gash in the range several miles east of its highest point (Seven Weeks' Poort Mountain) marks the passage of the Gamka, whose two chief feeders are bridged at Bloed River Siding (Dwyka) and near Fraserburg Road. The traveller will rarely have the opportunity of seeing any water in either of these river beds, and he may be sceptical as to the power of their temporary streams to

cut such a gap in a mountain range. After heavy rain the sand and gravel of rivers like these are pushed or carried forward long distances, and the force of the current is immense; then it must be remembered that the age of this river system is very great, even in a geological sense, and that the vigour of the streams has been renewed more than once by elevation of the country. A smaller but sharply defined gap west of the Gamka Poort is the Seven Weeks' Poort, close under the highest point of the range. A third gorge, to the east of the Gamka Poort, is Meiring's Poort. The Buffel's River Poort is not well seen from the railway line. To the north the view is closed by the great cliffs of the Nieuweveld escarpment, capped by massive and roughly columnar sheets of intrusive dolerite. The highest point is Bulthouders Bank, 6,270 feet above the sea. As Beaufort West (2,850 feet) is approached the details of the structure of the cliffs become more and more obvious, and a second thick sheet considerably lower than the uppermost one, can be distinguished. It caps the high plateau projecting far from the mountain west of the town of Beaufort. In reality there are three thick sheets near the town, but the highest one cannot be distinguished from the second till Beaufort West is left. For many miles along the line beyond Prince Albert Road two mountains at the western end of the Nieuweveld cliffs are very conspicuous, one is Tafel Berg, a flat-topped mountain crowned by a columnar sheet of dolerite 400 feet thick, and rising 3,000 feet from the ground at its base, and the second is the pointed Spitz Kop, slightly lower than Tafel Berg

but capped by a remnant of the same sheet. These are outliers of the sheet at the top of the extreme western part of the Nieuweveld. Just beyond the Beaufort Station the line crosses a thick dolerite dyke inclined northwards; it has been cut through to allow the railway to pass; to the east a corresponding section is visible at the end of the wall of the town dam. The Beaufort dyke, as it is called, has been traced for several miles each side of the town, and on the west it appears to have supplied the second of the dolerite sheets mentioned above.

A few miles south-west of Prince Albert Road the line passes over the boundary between the Ecca and Beaufort beds; no conspicuous feature marks its position, but north of it the remains of *Pareiasaurus* and other reptiles are found. The *Dicynodon* beds are passed over beyond Beaufort West.

After traversing the wide alluvial flats beyond Beaufort the line ascends the main Colonial watershed, which is crossed near Biesjes Poort. Along this section dolerite sheets are the most conspicuous features in the country; the great variety in the shapes of mountain sides and kopjes is due to the progress of denudation in a rock mass of horizontal strata with sheets and dykes of dolerite. The reddish or deep brown boulders, often many feet in diameter and covered with a thin varnish of black oxides of iron on their most exposed surfaces, are portions of the dolerite separated from their parent outcrops by the weather.

From the watershed to the Orange River, both on the Kimberley and Johannesburg lines, the train runs across

wide flats where outcrops are hardly to be found, with flat-topped dolerite or sandstone-capped hills in the distance, then it approaches groups of these hills and winds its way between them. The geology of this part of the Colony as far east as Stormberg Junction has not been examined in detail. The most remarkable features near the railway in this district are the two flat-topped hills, Theebus and Coffeebus, between Rosmead Junction and Steynsburg; they owe their form to the presence of dolerite caps which have protected the softer sedimentary beds below.

From Rosmead the Port Elizabeth line follows the valley of the Great Fish River as far as Commadagga, a distance of over a hundred miles, lying upon the Karroo formation all the way. At Commadagga the Dwyka series is traversed; the similarity in character of that rock at Matjes Fontein and in the Eastern Province can be noticed. The survey of the country through which this line passes has not yet been made. One of the points of interest in travelling across the Karroo formation a second time many miles to the east of the western main line is the difference in vegetation connected with the different climates in the two regions, and the distinction is still more marked when a comparison is made with the country traversed by the East London line below Queenstown, where grass veld predominates over bush. Below Commadagga the Witteberg beds are seen on either side of the line as far as Sand Flats, but near Alicedale, a syncline of the Dwyka, the western end of the Grahamstown syncline is traversed. At Sand Flats the railway enters the area of

the Uitenhage beds and remains in it as far as the Zwartkops bridge, from that place to Port Elizabeth the low ground near the line is formed of superficial deposits, chiefly raised beaches. From the bridge over Sunday's River may be seen the light-coloured cliffs of the Sunday's River beds containing marine fossils.

The line from Alicedale to Grahamstown and thence to Port Alfred lies on the Witteberg beds for the greater part of the distance, but near Grahamstown it traverses the Dwyka conglomerate for a few miles. In that neighbourhood a well-preserved terrace, north of the line, can be seen from the railway. The bridge over the Blaauw Krantz River, a tributary of the Kowie, is built just to the north of a rather fine gorge through the folded Witteberg quartzites; this gorge is analogous to the far greater poorts of the Buffel's, Gamka and other rivers in the Zwartebergen and Langebergen, through which the Great Karroo is drained.

The East London line descends the southern flank of the main watershed at Bushman's Hoek, and an excellent view of the almost precipitous face of the escarpment is obtained from the train. To the east of this region the Stormberg series is well developed, but near the railway only the Molteno beds are seen; the spoil heaps at the entrance to drives and pits near Molteno and Cyphergat mark the coal mines. The most striking features of the Stormberg series, the Cave sandstone and volcanic beds, are not seen near this line. The Karroo formation with its intrusions of dolerite extends to the coast at East London, but no detailed surveys have yet been made in that part of the Colony.

ROSMEAD TO PORT ELIZABETH AND OUDTSHOORN *VIA* KLIPPLAAT.[1]

Leaving Rosmead (4,044 feet), the railway passes over high veld covered with grass and small bush; dolerite sheets cover the tops of the hills, and lines of kopjes mark the courses of the dolerite dykes. Passing Middelburg, the line approaches the escarpment of the Sneeuwberg, and is taken over the edge a little to the east of the highest point in the range, Compass Berg (8,500 feet), and indeed the highest in the Colony, with the exception of some peaks on the Drakensberg. The escarpment is formed of a sheet of dolerite capping the Karroo rocks; it is at the edge of the plain that slopes to the Orange River, and the edge forms the main watershed dividing the streams flowing north and south. Graaff Reinet (2,463 feet), lies on the lowest slopes of the escarpment, the precipitous part of which may be reckoned at 1,000 feet. After winding down the face of the cliff, the line is taken along the banks of a stream, and the sides of the hills are steep and heavily charged with dolerite sheets, which give the gorge a wild and forbidding appearance. The dolerite, both when capping the hill tops, or exposed on a level with the river, is coarsely columnar, and gives rise to fantastically shaped pillars. The prickly pear has taken possession of the veld, and renders much of it useless. Springs come to the surface all along the river, and there is ample water for irrigation, but there is very little soil on which to use it, as only very narrow patches of alluvium occur;

[1] This section was given me by Mr. E. H. L. Schwarz.

nearing Graaff Reinet, however, these patches become larger and are covered with lucerne lands.

At Graaff Reinet the line leaves the mountains and the dolerite. On the east of the town are the Tandjes Bergen, the capping sheet of dolerite looking from a distance like the teeth of a saw, and on the west is a fine conical hill, Spander's Kop, with a crown of sandstone which has been hardened by dolerite and forms a vertical cliff all round; the dolerite now forms only an inconsiderable heap of boulders on top of the sandstone; to the north, however, the full thickness of the same dolerite sheet can be seen, and the celebrated Valley of Desolation is cut in it.

Leaving Graaff Reinet, the line runs over a wide plain formed of a peculiar variety of Karroo sandstone and shale, the surface of the ground being sandy and littered with small fragments of silicified wood, chert and limestone, till Klipplaat is reached. One branch goes down to Uitenhage and Port Elizabeth, passing the Dwyka conglomerate at Mount Stewart, and the Witteberg beds between there and Barroe, and thence it descends into the low-lying coast country made up of the various members of the Uitenhage series, Enon conglomerate, Wood bed, etc., the older rocks occasionally appearing at the surface.

At Uitenhage the marine beds of the Uitenhage series occur with many fossils, and the plateau that reaches the coast is here seen. Leaving Uitenhage the line follows the Zwartkops River; on the left are cliffs cut in the marine beds and levelled at the top. Great beach deposits lie on the plateau about here, and

nearer the coast the shell beds contain a large species of *Pectunculus.* Some distance away in among the beach deposits on top of the plateau is the celebrated Zwartkops Salt Pan. On the right there are ridges of red and variegated marls which are used for tile making, and away to the west the corresponding cliffs, level topped and beach covered, are seen. At their foot lies the Bethelsdorp Salt Pan.

The other branch of the line leaves Klipplaat to go to Willowmore and Oudtshoorn. The line approaches the hills at a very acute angle and before reaching them passes between kopjes made of Ecca (mottled) on the north and Dwyka conglomerate on the south. The pillowy and pinnacled features of the latter are well shown, but the "White band" that lies on the top of the conglomerate is badly exposed and is only noticeable from the white chert that occurs in it.

The line then enters the Witteberg hills at Swanepoel's Poort. The Witteberg quartzites are bent into acute folds, but the tops of the hills have been cut more or less level and in places great open grassy flats occur between them. The folds repeatedly bring the Dwyka shales and the conglomerate to the level of the Plessis River, along which the embankment is carried, and the axis of the folds being east and west the valleys are likewise in that direction. At Waai Kraal there is a very wide syncline filled with Dwyka conglomerate and the shales immediately above and below it. The line then passes through a poort and enters a flat country covered with deep red soil derived from the weathering of the Bokkeveld beds. The line steadily rises and

approaches the ridges of hills formed of folded Bokkeveld beds, the sandstones of which look very much like those of the Witteberg, but the amount of clay-slate and shale between them is greater. After passing through a small poort in these hills the train runs into Willowmore.

From Willowmore there is a long stretch of country formed of folded Bokkeveld beds and then the line turns round and makes straight for a narrow slit in the mountains. These mountains are the eastern end of the Zwartebergen, and are composed of Table Mountain sandstone; the tremendous folding and crumpling observable in the Zwartberg Pass and Meiring's Poort have died out, though even here the beds stand vertical. The slit is Tover Water's Poort, through which runs the Traka River. On the south side of the mountains there is again a tract of Bokkeveld hills to the east, but to the west the Enon conglomerate occupies a considerable area. On the outcrop of the junction of the Table Mountain sandstone and the Bokkeveld to the east there is a hot spring. The line is carried over the Bokkeveld beds past Uniondale Road and past the bend along the Olifant's River. On the Oudtshoorn side of the bend there are high krantzes of red Enon conglomerate, which rock, however, soon crosses the river and the overlying white Enon forms the centre of the valley. To the north are the Zwartebergen with a very characteristic shelf or old river plateau high up on the mountain side; to the south, in the distance, are the Kammanassie Mountains, also made of the Table Mountain sandstone, and between them and the line

are first, kopjes of the Bokkeveld beds, then red Enon and then white Enon conglomerate. The same features extend past Vlakte Plaats, where the line enters a tract of Bokkeveld and skirts a peculiar inlier of Table Mountain sandstone; then it passes by the mouth of Meiring's Poort, but between the poort itself and the line there are high hills of Cango beds cut to a level top and capped with river gravel. To the south the end of the Kammanassie Mountains can be seen where the village of Dysseldorp stands. Thence to Oudtshoorn one passes through red Enon, white Enon and finally the sandy beds above the last.

The Eende Kuil and Hopefield Lines.

Leaving the main line at Kraaifontein the Malmesbury branch traverses undulating country cut out of the Malmesbury beds as far as the town of that name, where granite is met with. At Klipheuvel, a faulted outlier of Table Mountain sandstone, the continuation of Joostengerg is crossed.

At Kalabas Kraal the Hopefield railway branches off from the Malmesbury line. The great granite masses of Paarde Berg and Dassen Berg form considerable hills to the east and west of the line near Kalabas Kraal. The Dassen Berg mass is followed as far as Darling where the line turns northwards through the Zwartland, a flat grain country of little geological interest, as far as Hopefield.

From Malmesbury the Eende Kuil line skirts the eastern edge of the Zwartland, and some good sections of the sericitic slates of the Malmesbury series are ex-

posed in the cuttings. The structure of the wide extent of Malmesbury beds which stretch from the west flank of the Olifant's River and Cardouw's Mountains to Piquetberg and the Saldanha Bay granite is not understood. These beds are intensely folded and consist of phyllites with occasional interbedded layers of grits and quartzites. From the Berg River Bridge to Eende Kuil fine views of the escarpments of Piquetberg and the Olifant's River Mountains can be seen from the train.

Caledon Line.

Leaving the main line at Durban Road the railway passes the granite of Kañon Kop and Papagaai's Berg and the Helderberg outlier of Table Mountain sandstone; it skirts the eastern part of the Cape Flats. Near Somerset West a small but interesting granite mass is passed about two miles on the down side of the station; this granite contains much tourmaline, andalusite, and other accessory minerals. Beyond Sir Lowry's Pass the line ascends the steep sandstone escarpment of Hottentot's Holland and enters the Grabouw-Houw Hoek area of Bokkeveld beds, a more or less quadrangular sunken tract defined by north-west and north-east lines of folding. The Bot River Valley is gained by the Houw Hoek Pass and from that river to Caledon the line runs over the Bokkeveld beds. The rugged mountain of Table Mountain sandstone near Caledon is an anticline, to the south the sandstone again rises from below the Bokkeveld beds in the Babylon's Tower Range, and to the north in the Zonder Einde Mountains.

The Riversdale Line (Cape Central Railway).

This line leaves the Government Railway at Worcester. The Ecca beds are seen near Worcester Station, but for some distance to the east nothing but river gravels and occasional banks cut into the Uitenhage conglomerates (Enon type) which are not easily distinguishable from river gravels from the train, can be seen from the railway. Near Nuy Siding the Ecca beds are again seen, and at Lange Vley the line passes on to the Dwyka series. From Vink River to Robertson the Witteberg, Bokkeveld, and Table Mountain sandstone are traversed. The high hill to the north of the railway between Vink River and Robertson is a great mass of granite intrusive in the Pre-Cape rocks (Malmesbury series) north of the Worcester fault which makes a bend round it. The Cape and Karroo formations abut against the fault in this region, having been folded in a north-easterly direction on the down-throw side. Between Robertson and Ashton the railway crosses an outlier of the Enon conglomerates which cover the great fault in this neighbourhood. From Ashton to Swellendam Bokkeveld and Witteberg beds are seen, the latter form the conspicuous hills with thick groups of quartzite beds. Near Swellendam an ill-defined Uitenhage outlier is crossed, and yet another is entered at Slang River; from there to Riversdale excellent sections through the clays, shales, and conglomerates of the Uitenhage beds are exposed in the cuttings; fossils have been obtained from several of those cuttings. East of Swellendam numerous extensive gravel plat-

eaux lying high above the rivers are seen, and small outliers of them form the table-shaped hills characteristic of the Ruggens—the hilly country between the Zonder Einde and Langebergen on the north and the coast mountains on the south.

APPENDIX.

List of books and papers referred to in the body of the work:—

Abel, C. *Narrative of a Journey in the Interior of China*, chap. xi. London, 1818.

Amalitzky, W. "A Comparison of the Permian Freshwater Lamellibranchiata from Russia with those from the Karoo System of South Africa," *Quart. Journn. Geol. Soc.*, p. 337., 1895.

—— *Sur les Fouilles de 1899 de Dêbris de Vertêbrês dans les Dêpôts Permiens de la Russie du Nord.* Warsaw, 1900.

Anderson, W. *First Report of the Geological Survey of Natal and Zululand.* Pietermaritzburg, 1901.

Atherstone, W. G. "Geology of Uitenhage," *The Eastern Province Monthly Magazine*, vol. i., pp. 518 and 580. Grahamstown, 1857.

—— "A Geological Tour from Grahamstown to the Kasouga," *Cape Monthly Magazine*, 1st series, vol. iv., pp. 273-282 and 328-334. Cape Town, 1858.

Baily, W. H. "Description of some Cretaceous Fossils from South Africa Collected by Capt. Garden of the 45th Regiment," *Quart. Journ. Geol. Soc.*, xi., p. 454, 1855.

Bain, A. G. "On the Geology of Southern Africa," *Trans. Geol. Soc.*, 2nd series, vol. vii., p. 175, 1856; with appendices: by D. Sharpe on the "Fossils from the Secondary Rocks of Sunday River and Zwartkop River"; by D. Sharpe and J. W. Salter on "Palæozoic Fossils from South Africa"; by D. Sharpe, J. D. Hooker and Sir P. Egerton on "Some Fossils from the Karoo Desert and Its Vicinity".

Blanford, H. F. and W. T., and Theobald, W. "On the Geological Structure and Relations of the Talcheer Coal Field, in the District of Cuttack," *Memoirs of Geol. Survey of India*, vol. i., p. 33, 1859.

Bonney, T. G. "The Parent-rock of the Diamond in South Africa," *Geol. Mag.*, p. 309, 1899.

Broom, R. "On an almost Perfect Skeleton of *Pareiasaurus serridens*, Owen," and five other papers, in *Ann. of the South African Museum*, vol. iv., pt. ii., 1903. Also many papers in *Trans. S. A. Phil. Soc.*, vols. xi.-xv., *Records of the Albany Museum*, and *Report of the South African Association for the Advancement of Science*, vol. i.

Chapman, F. "Foraminifera and Ostracoda from the Cretaceous of East Pondoland, South Africa," *Ann. of the South African Museum*, vol. iv., pt. v., 1904.

Cohen, E. Letters to the Editor, *Neues Jahrbuch für Min.*, etc., p. 857, 1872; and p. 52, 1873.

—— "Geognostisch-petrographische Skizzen aus Süd-Afrika," *Neues Jahrbuch für Min.*, etc., p. 460, 1874; and Beilage-band, v., p. 195, 1887.

Corstorphine, G. S. C. See *Geol. Commission, Annual Reports.*

Daniell, G. W. B. "The Mineral Waters of Caledon," *South African Medical Journal*, vol. ii., p. 242, 1895.

Dunn, E. J. *Report on a Gold Prospecting Expedition in Namaqualand*, Parliamentary Report, G. 21. Cape Town, 1872.

—— "On the Mode of Occurrence of Diamonds in South Africa," *Quart. Journ. Geol. Soc.*, xxx., p. 54, 1874.

—— *Report on Camdeboo and Nieuweveldt Coal.* Parliamentary Report, G. 37. Cape Town, 1879.

—— *Report on the Stormberg Coal Fields*, Parliamentary Report, G. 8. Cape Town, 1878.

—— *Report on a Supposed Extensive Deposit of Coal Underlying the Central Districts of the Colony*, Parliamentary Report, G. 8. Cape Town, 1886.

—— "Notes on the Dwyka Coal Measures at Vereeniging, Transvaal," *Trans. S. A. Phil. Soc.*, xi., p. 67, 1900.

—— Geological Sketch Map of Cape Colony. London, 1872.

—— Geological Sketch Map of South Africa. London, 1875.

—— —— Melbourne, 1887.

Feistmantel, O. "Uebersichtliche Darstellung der Geologisch-Palaeontologischen Verhältnisse Süd-Afrikas" (I. Theil), *Abh. der königl. böhm. Gesellschaft der Wiss.*, vii. Folge, 3 Band, 1889.

Geological Commission, Annual Report of, for 1896. Cape Town, 1897.

—— For 1897. Cape Town, 1898.

—— For 1898. Cape Town, 1900.

—— For 1899. Cape Town, 1900.

—— For 1900. Cape Town, 1901.

—— For 1901. Cape Town, 1902.

—— For 1902. Cape Town, 1903.

—— For 1903. Cape Town, 1904.

Gervais, P. *Description du Mesosaurus tenuidens, Reptile fossile de L'Afrique australe.* Montpellier, 1865.

Graichen, W. "Die Diamentminen Süd-Afrikas," *Zeitschrift für prakt. Geologie*, p. 448, 1903.

Green, A. H. *Report on the Coal Fields of the Cape Colony*, Parliamentary Report, 1883.

—— "A Contribution to the Geology and Physical Geography of the Cape Colony," *Quart. Journ. Geol. Soc.*, xliv., p. 239, 1888.

Griesbach, C. L. "On the Geology of Natal in South Africa," *Quart. Journ. Geol. Soc.*, xxvii., p. 53, 1871.

Gumprecht, T. E. *Die Mineralquelle auf dem Festlande von Africa*, etc. Berlin, 1851.

Hochstetter, F. v. "Beiträge zur Geologie des Caplandes," *Reiser der Österreichischen Fregatte Novara um die Erde*, Geol. Theil, vol., ii., p. 19. Vienna, 1866.

Holub, E., and Neumayr, M. "Ueber einige Fossilien aus der Uitenhage-Formation in Süd-Afrika," *Denk. der Math.-naturwissenschaftlichen classe der Kaiserlichen Akad. der Wissenschaften.* Vienna, 1881.

Huxley, T. H. "On Saurosternon Bainii and Pristerodon McKayi, two new fossil Lacertilian Reptiles from South Africa," *Geol. Mag.*, vol. v., p. 201, 1868. This paper contains sections and notes by Mr. McKay illustrating the Geology of East London. Other papers by Huxley dealing with Karroo Reptiles will be found in vols. xv., xxiii., xxvi., of the *Quart. Journ. Geol. Soc.*

Jack, R. L., and Etheridge, R. *The Geology and Palæontology of Queensland and New Guinea.* London, 1892.

Johnson, J. P. "Notes on Sections at Shark River and the Creek, Algoa Bay," *Trans. Geol. Soc. S.A.*, vi., p. 9, 1903.

Jones, T. R. "On the Enon Conglomerate of the Cape of Good Hope and its Fossil Esthoriae," *Geol. Mag.*, p. 350, 1901.

Kalkowsky, E. "Die Verkieselung der Gesteine in der nördlichen Kalahari," *Abh. der naturwiss. Gesellschaft "Isis" in Dresden*, 1901.

Kossmat, F. "On the Importance of the Cretaceous Rocks of Southern India in Estimating the Geographical Conditions during late Cretaceous Times," *Trans. in Records Geol. Surv. of India*, xxviii., p. 39, 1895.

Krauss, F. "Ueber einige Petrefacten aus der untern Kreide des Kaplandes," *Nova Acta Acad. Caes. Leop.-Car. Nat. Cur.*, xxii., p. 441, 1847.

—— "Ueber die Quellen des Südlichen Afrika's," *Neues Jahrbuch für Min.*, etc., p. 150, 1843.

Lacroix, A. "Note sur les Minéraux et les Roches du Gisement diamantifere de Monastery (État libre d'Orange) et sur ceux du Griqualand," *Bull. Soc. Franc. Min.*, xxi., pp. 21-29, 1898.

Lake, P. "The Trilobites of the Bokkeveld Beds," *Ann. of the South African Museum*, vol. iv., pt. iv., 1904.

Launay, L. de. *Les Diamants du Cap*. Paris, 1897.

—— *Les Richesse Minérales de l'Afrique*. Paris, 1903.

Lewis, Carvill. *Papers and Notes on the Genesis and Matrix of the Diamond*, edited by Professor T. G. Bonney. London, 1897.

Lydekker, R. *Catalogue of the Fossil Reptilia in the British Museum*. London, 1888-1890.

Molengraaff, G. A. F. "Géologie de la République Sud-Africaine du Transvaal," *Bulletin de la Société Géologique de France*, 4th series, vol. i., p. 13, 1901.

—— "The Glacial Origin of the Dwyka Conglomerate," *Trans. Geol. Soc. S. A.*, vol. iv., pt. i., p. 103, 1895.

Molyneux, W. *Report on the Geology of the Karoo and Stormberg*, Parliamentary Report, G. 71. Cape Town, 1881.

Moulle, A. "Mémoire sur la Géologie générale et sur les mines de diamants de l'Afrique du Sud," *Annales des Mines*, 8th series, vol. vii., p. 193, 1885.

Mügge, O. "Ueber einige Gesteine des Massai-Landes," *Neues Jahrbuch für Min.*, etc., Beilage-band iv., p. 603, 1886.

Neumayr, M., and Holub, E. "Ueber einige Fossilien aus der Uitenhage-Formation in Süd-Afrika," *Denk. der Math.-naturwissenschaftlichen classe der Kaiserlichen Acad. der Wissenschaften.* Vienna, 1881.

Newton, R. B. "On the Occurrence of Alectryonia ungulata in S. E. Africa, with a Notice of Previous Researches on the Cretaceous Conchology of Southern Africa," *Journ. of Conchology*, p. 136, 1895.

Noble, J. *Official Handbook of the Cape and South Africa.* Cape Town, 1893.

North, F. W. *Report on the Coal Fields of the Stormbergen*, Parliamentary Report, G. 47. Cape Town, 1878.

Osborne, C. F., and Bain, T. *Report on Gold Discoveries in the Knysna Division*, Parliamentary Report, G. 46. Cape Town, 1886.

Owen, R. *Descriptive and Illustrative Catalogue of the Fossil Reptilia of South Africa in the Collection of the British Museum.* London, 1876. Also many papers in the *Quart. Journ. Geol. Soc.* between 1845 and 1887.

Penck, A. "Die Eiszeiten Australiens," *Zeitsch. Gesellsch. f. Erdk.*, xxxv., p. 239. Berlin.

Pinchin, R. "A Short Description of the Geology of Part of the Eastern Province of the Colony of the Cape of Good Hope," *Quart. Journ. Geol. Soc.*, vol. xxxi., p. 106, 1875.

Playfair. "Account of the Structure of Table Mountain, and Other Parts of the Peninsula of the Cape, from Observations by Capt. Basil Hall, R.N.," *Trans. Roy. Soc. Edin.*, vol. vii., p. 269.

Prior, G. T. "Contributions to the Petrology of British East Africa," etc., *Mineralogical Magazine*, xiii., p. 228, 1903.

Prosser, W. "Limestones of the Colony," *Trans. S. A. Phil. Soc.*, vol. i., pt. ii., p. 47, 1879.

Reed, F. R. C. "Brachiopoda from the Bokkeveld Beds," *Ann. of the South African Museum*, vol. iv., pt. iii., 1903.

—— "Mollusca from the Bokkeveld Beds," *Ann. of the South African Museum*, vol. iv., pt. vi., 1904.

Reichenbach, E. Fr. Stromer v. *Die Geologie der Deutschen Schutzgebiete in Afrika.* Munich and Leipzig, 1896.

Rogers, A. W. "On a Glacial Conglomerate in the Table Mountain Sandstone," *Trans. S. A. Phil. Soc.*, vol. xi., p. 236, 1902.

Rogers, A. W. "The Geological History of the Gouritz River System," *Trans. S. A. Phil. Soc.*, vol. xiv., p. 375, 1903.

—— and Schwarz, E. H. L. "Notes on the Recent Limestones on Parts of the South and West Coasts of Cape Colony," *Trans. S. A. Phil. Soc.*, vol. x., p. 427, 1899.

—— —— "The Orange River Ground-Moraine," *Trans. S. A. Phil. Soc.*, vol. xi., p. 113, 1900.

—— —— "The Transkei Gap," *Trans. S. A. Phil. Soc.*, vol. xiv., p. 66, 1903.

—— and du Toit, A. L. "The Volcanic Pipes of Sutherland and Their Relationship to Other Vents in South Africa," *Trans. S. A. Phil. Soc.*, vol. xv., 1904.

Rosenbusch, H. *Mikroskopische Physiographie der Massigengesteine.* Stuttgart, 1896.

Rubidge, R. N. "On Some Points in the Geology of South Africa," *Quart. Journ. Geol. Soc.*, xv., p. 195, 1859.

Schenck, A. "Die geologische Entwickelung Südafrikas," *Petermann's Mittheilungen*, vol. xxxiv., p. 225, 1888.

—— "Ueber die Kupferzlagerstätte von Ookiep in Klein Namaland," *Zeitschrift der deutsch geol. Gesellschaft*, p. 64, 1901.

Schwarz, E. H. L. "The Volcanoes of Griqualand East," *Trans. S. A. Phil. Soc.*, vol. xiv., 1903.

—— "An Unrecognised Agent in the Deformation of Rocks," *Trans. S. A. Phil. Soc.*, vol. xiv., 1903.

—— "High-level Gravels of Cape Colony and the Problem of Karroo Gold," *Trans. S. A. Phil. Soc.*, vol. xv., 1904.

—— and Rogers, A. W. "Notes on the Recent Limestones on Parts of the South and West Coasts of Cape Colony," *Trans. S. A. Phil. Soc.*, vol. x., p. 427, 1899.

—— —— "The Orange River Ground-Moraine," *Trans. S. A. Phil. Soc.*, vol. xi., p. 113, 1900.

—— —— "The Transkei Gap," *Trans. S. A. Phil. Soc.*, vol. xiv., p. 66, 1903.

Seeley, H. G. "Researches on the Structure, Organisation and Classification of the Fossil Reptilia" (pts. i.-ix.), *Phil. Trans. Roy. Soc.*, vols. 178-186, 1887-1895.

—— "On Bubalus Bainii," *Geol. Mag.*, p. 199, 1891.

—— "The Mesosauria of South Africa," *Quart. Journ. Geol. Soc.*, xlviii., p. 586, 1892. Papers in *Quart. Journ. Geol. Soc.*, vols. xxxiv., xlviii., and *Ann. and Mag. Nat. Hist.*, xv., 1895.

Story-Maskelyne, N., and Flight, W. "On the Character of the Diamantiferous Rock of South Africa," *Quart. Journ. Geol. Soc.*, xxx., pp. 406-416, 1874.

Stow, G. W. "On Some Points in South African Geology," *Quart. Journ. Geol. Soc.*, xxvii., p. 497, 1871.

—— "Geological Notes upon Griqualand West," *Quart. Journ. Geol. Soc.*, xxx., p. 581, 1874.

Sutherland, P. C. *On the Geology of Natal (South Africa).* Durban, 1868.

—— "Notes on an Ancient Boulder-Clay of Natal," *Quart. Journ. Geol. Soc.*, xxvi., p. 514, 1870.

Tate, R. "On Some Secondary Fossils from South Africa," *Quart. Journ. Geol. Soc.*, xxiii., p. 139, 1867.

Du Toit, A. L., and Rogers, A. W. "The Volcanic Pipes of Sutherland and Their Relationship to Other Vents in South Africa," *Trans. S. A. Phil. Soc.*, vol. xv., 1904.

Williams, G. F. *The Diamond Mines of South Africa*, etc. New York, 1902.

Wyley, A. *Report upon the Maitland Mines near Port Elizabeth*, Parliamentary Report, G. 5. Cape Town, 1856.

—— *Report upon the Mineral and Geological Structure of South Namaqualand and the Adjoining Mineral Districts*, Parliamentary Report, G. 36. Cape Town, 1857.

—— *Report of the Geological Surveyor upon a Journey Made by Him, mainly during the Year 1858, in Two Directions across the Colony, and Its Results*, with an appendix containing a detailed account of the journey, Parliamentary Report, G. 54. Cape Town, 1859.

Zirkel, F. *Lehrbuch der Petrographie*, 3 vols. Leipzig, 1893.

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